PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. XII. 1883-84. No. 115.

GENERAL STATUTORY MEETING.

Monday, 26th November 1883.

THOMAS STEVENSON, Esq., Vice-President, in the Chair.

The following Council were elected:—

President.

The Right Hon. LORD MONCREIFF.

Vice-Presidents.

Prof. H. C. Fleeming Jenkin, F.R.S.
Rev. W. Lindsay Alexander, D.D.
Thomas Stevenson, M.Inst.C.E.
Robert Gray, Esq.
A. Forbes Irvine, Esq. of Drum.
Edward Sang, LL.D.

General Secretary—Professor Tait.

Secretaries to Ordinary Meetings.

Professor Turner, F.R.S.
Professor Crum Brown, F.R.S.

Treasurer.—Adam Gillies Smith, Esq., C.A.

Curator of Library and Museum—Alexander Buchan, Esq., M.A.

Councillors.

Rev. Professor Duns.
Dr Ramsay Traquair.
John Murray, Esq.
Wm. Ferguson, Esq. of Kinmundy.
Professor Cossar Ewart.
Professor James Geikie, F.R.S.
Rev. Dr W. Robertson Smith.
Stair Agnew, Esq., Registrar-Gen.
Prof. Douglas Maclagan, M.D.
The Hon. Lord MacLaren.
Rev. Professor Flint, D.D.
Professor T. R. Fraser, M.D.

By a Resolution of the Society (19th January 1880) the following Hon. Vice-Presidents, having filled the office of President, are also Members of the Council:—

His Grace the DUKE of ARGYLL, K.T., D.C.L.
Sir WILLIAM THOMSON, LL.D., D.C.L., F.R.S., Foreign Associate of Institute of France.

BRITISH MUSEUM

Monday, 3rd December 1883.

THE RIGHT HON. LORD MONCREIFF, President,
in the Chair.

The following Communications were read:—

1. An Essay upon the Limitations in Time of Conscious Sensations. By John B. Haycraft, M.B. Edin., F.R.S.E., &c.; Professor of Physiology in the Mason Science College, and Lecturer on Physiology at Queen's College, Birmingham.

I propose to describe in this essay some experiments which I have conducted upon the limits in time of separate tactile and thermal sensibilities. I shall endeavour to account for the variations seen in the limitations in conscious sensation of the different senses; and also to formulate a general proposition as to the effect on consciousness of stimuli increasing gradually in rapidity of application.

If the finger be touched with a pin, one is both conscious of the point in time at which the contact is made, and also when it is broken; this is likewise true of the other sensations. In the case of hearing, for example, a note struck upon the pianoforte is localised in time as of a certain duration. In moving an object through the field of vision, it is seen definitely to pass into, and also out of that field.

There is, however, a limit to this which can be determined, for if the image just alluded to be brought—by means of a revolving wheel—fifteen or twenty times a second in front of the same point of the visual field, it will now be seen as a stationary object, and the separate stimuli will produce a continuous sensation. In the case of hearing, Helmholtz has shown (*The Sensation of Tone as a Physiological Basis for the Theory of Music*, p. 262) that the limits in time are sharper and more exact. The ear can, according to this observer, distinguish 132 beats (produced by high notes) in a second; even this being probably not the extreme limit. It is also known that over 1400 impacts from a revolving toothed wheel must affect the finger tip in a second, before the sensations are completely fused in consciousness; and before it becomes indistinguishable from a revolving smooth metal disc.

It is, then, to be noted that stimuli, separate in themselves, are, when sufficiently rapid, formulated in consciousness as continuous and uninterrupted; and that this fusion occurs sooner in the consciousness of some sensations than in others.

Some experiments which I have lately performed shed, I think, some light on these facts, and enable us to state them in greater amplitude; above all indicating *where* the fusion occurs. I may anticipate by stating that this is during the transformation of the stimuli into nerve energy.

My experiments have been chiefly concerned with the investigation of the results in consciousness of repeated stimulation of the nerves of tactile and thermal sensibilities, the apparatus being usually of the simplest possible kind.

The skin was stimulated interruptedly in many ways, either by tuning forks of various degrees of pitch, or by a revolving toothed wheel. The most satisfactory results, however, were obtained by a vibrating steel rod fixed in an iron vice. By altering its fixed point, and therefore the length of the vibrating portion, the period of its vibrations, and the impacts made upon the finger tip held near its free end, could be altered at will. Its exact pitch was easily obtained by attaching to it a light writing style which recorded its vibrations on a revolving smoked cylinder.

If the finger be pressed lightly upon a revolving toothed wheel, whose motion is made to increase slowly in rapidity, the following sensations may be noted. When no more than forty or fifty taps are made upon the finger in a second, there is produced a consciousness of distinct stimuli, separated one from another by periods of rest. Each stimulus produces a distinct sensation, limited in time from the one that follows. Stimulate more rapidly, and it becomes no longer possible to distinguish in consciousness one stimulus from another. They give rise, however, to a sensation which we term "roughness," which becomes less marked—less rough—as we increase the rapidity of the revolving wheel. If, at this point, the fingers be very gently pressed against the wheel, there is a sensation of tickling—such as that produced by drawing a feather over the face. If, as a final step in the experiment, we cause the wheel to revolve very rapidly, the sensation becomes less rough, and, at last, when as many as 1400 impacts are made upon the finger tip, the sensation cannot be distinguished from that of a revolving toothless metal disc. There is, in fact, a sensation of "smoothness," which, but for the shearing produced upon the skin, could not be distinguished from the "touch" of a stationary smooth metal surface. We see then that three distinguishable conditions are produced by stimulating the skin more and more rapidly. At first, each stimulation is formulated separately in consciousness, then we have a sensation of roughness, and finally one of smoothness.

Before proceeding further it will be well to insist upon the fact, that when we consider the subject more generally, we can find analogous conditions in the other sensations. There is certainly in hearing and sight, for instance, a period of "roughness," which is irritating in its nature, and is a distinct sensation preceding the complete fusion of the stimuli in consciousness. Moreover, the nature of its cause is known only by experience gained from other sensations; it not being evident in the consciousness of the special sensations above mentioned.

The tick of a watch is not irritating—on the contrary, it may produce hypnotism. An alarum with more rapidly repeated sounds has a well known effect, upon which it will be needless to insist. My colleague, Professor Poynting, suggests that the very low notes of a large organ are, in like manner, irritating from their rapid intermittence. In the numbers quoted from Helmholtz, probably the "beats" are no longer separately heard, but produce the harsh dissonance which characterises them; a much lower number would indicate the number of stimuli which can be heard separately. This number I am unable to state, as a double syren is not in my possession.

Few things are more annoying than the flickering of a gas jet, or the slow vibration of a body which gives a blurred unsteady image. The tickling of a vibrating tuning fork held to the lips, or still more the tickling that results from stimulating in rapid succession adjacent points of the skin, is calculated in extreme cases to give excruciating agony.

A few minutes' consideration will also show that this condition of "roughness" is *not* a sensation of intermittent stimulation. That this is its cause is but a matter of experience aided by the use of the other senses. A child blowing the sharp edge of a piece of tissue paper stretched between its lips, remarks that "it tickles," but is quite unaware of the cause of the sensation. Again, on touching the rapidly revolving wheel, it is conscious only of a continuous sensation; but turn it more slowly, and it feels each separate tap.

We have then in tactile sensibility a condition analogous to the cause of dissonance in music, and to the annoying flickering of recurrent visual stimuli. Moreover, we can recognise degrees or qualities of this "roughness," a most important factor in adding to our knowledge of the external universe. On drawing a file, or the edge of a fine saw across the finger, the sensation is quite different from that produced by the back of a knife. Moreover, within limits, we can distinguish a coarse from a fine file. The sensation in each case is different, and experience especially gained by the use of the eye, tells us of the nature of the substance which has produced the feeling.

It is a well known fact that all parts of the skin are not equally sensitive. The skin of the finger-tips and the front of the hand can be stimulated by the impact of a lighter body than will affect the skin of the back of the hand. Again, the skin of the front of the arm is more sensitive than that of the dorsal surface, and still more so than the skin covering the back of the shoulders. Together with this difference in actual sensitiveness, the brain is unable to localise impacts which affect the less sensitive parts, so exactly as those which affect the more sensitive. As a result of this, two impacts made on points of the skin near enough may be fused into one in consciousness. If the points of a pair of compasses less than one millimetre apart touch the finger-tip they may be distinguished as two, the localisation of each point in consciousness being very exact. Over the back, however, the points must be removed for more than an inch before they can be distinguished. This difference, not to be discussed here, is probably due to the anatomical distribution of the peripheral nerves.

It becomes an interesting question whether the limits in time of conscious tactile sensations vary in like manner over different surfaces of the body.

As a result of my experiments I am led to believe that, whereas the limitations in space are widely different, this does not hold with the limitations in time.

If a rod vibrating about forty times in a second be held to the finger tips or lips, sensations of distinct impacts may be felt. Allow the rod to vibrate upon a surface less sensitive, and with much wider limitations in space, say the skin over the sternum, and the impacts are still felt as such. I should mention that, inasmuch as the skin is less sensitive, the amplitude of the vibrations, and therefore the force of the impacts, should be increased.

So far we have considered the limitation in time of tactile sensibility; but there remains another very important function of the skin, which we have to discuss. I refer to thermal sensibility.

On touching a good conductor, such as an iron ball, any difference of temperature will not at once be noted, the cold will not be felt instantly. On withdrawing the ball, the sensation of cold remains for a short time. The limits in time are very wide, for the application of the cold body on several successive occasions—even with intervals of a second—producing, of course, successive sensations of impact, gives rise to a continuous and uniform sensation of cold. If the good conductor be applied every second to the skin of the back or arm, distinct sensations of cold will be produced each time. This is not due to these parts being covered and sensitive to cold, for the same obtains with the thin skin between the fingers, and the back of the hand, although in a less degree. The difference must alone be due to the variations in thickness of the epidermis—a bad conductor—which separates the body touched from the nerve end-organs in the lower layers of the skin.

In studying these phenomena, I have used a very simple piece of apparatus. A long and slowly vibrating rod is fixed in an iron vice, and to its free end a small glass bottle is attached. This is fitted with a cork, through which passes an iron rod about half an inch wide. The bottle is filled with a mixture of ice and salt, which cools the rod in its whole length. The portion outside the bottle is caused to impinge upon the finger-tip periodically.

In order that the action of external stimuli may affect our consciousness, a certain period of time is necessary. This period varies with many factors which we propose to discuss. A correct estimation of the value of these factors is all the more necessary, as they are hopelessly confounded in most works on mental science.

We have, first, the irritation of the peripheral sensitive nerve; secondly, the transmission of some change thus produced in the nerve; and thirdly, that effect produced upon centrally placed nerve-cells associated with the production of feeling, and a consciousness of that feeling. The time elapsing between the impact of a body on the hand and the consciousness of that impact is much less than between the application of a drop of sugar solution to the tongue and the resulting sensation of sweetness. This period is different in the case of each sensation. On what does this depend? I shall endeavour to show that the dependence is not mainly on differences of time taken by the impression to pass along different nerves, nor need we look to differences affecting central cells; but we have, in the nature of the stimulus applied and in that of the stimulated end-organ, a cause which will account for everything.

Herbert Spencer, in his *Principles of Psychology* (vol. i. p. 169, third edition), would actually distinguish between peripherally initiated feelings caused by internal disturbances—some of which, he says, are extremely indefinite, and few or none definite in a high degree—and feelings caused by external disturbances which are mostly related quite closely, alike by coexistence and sequence, among the highest of them the mutual limitations in time and space or both being extremely sharp. He illustrates this by the fact that our states of consciousness in connection with vision and hearing are more sharply limited in time and space than those in connection with smell and taste, and, still more, hunger.

Now, discarding the fact that when considered developmentally the retina at any rate is far more *internal* than the mouth and nose, the former being really a portion of the brain, the latter puckerings-in of the surface, I would suggest, that the all-important factor producing this difference, is not the brain, or the produced feelings, as Herbert Spencer seems to me to indicate, but the nature of the peripheral end-organ stimulated. If the point of a pin impinges upon the finger tip, the epithelium is depressed, and at the same time the nerves of tactile sensibility are stimulated; and on withdrawing the pin, they are at that moment unstimulated, and in a condition of rest. Also in the ear, the sound vibrations travelling rapidly into the internal ear cause the structures there (the basilar membrane and rods of Corti) to vibrate, and—as we are aware from our knowledge of the action of one vibrating body upon another—they do this very rapidly.

Far otherwise with the senses of smell and taste. When odorous particles pass into the olfactory or upper part of the nasal cavity—in which the nerves of smell are placed—it is by diffusion from the lower or respiratory part of the nose. If the breath be held, and a piece of incense paper be burnt in front of the face, some time may elapse before the scent is perceived, because the odorous particles have in fact to diffuse into a closed sac. If, on the other hand, the experimenter "sniffs" the air, the stimulus will be more rapidly perceived, because the odorous particles are carried rapidly through the lower chamber of the nose, inducing out-currents from the upper chamber, which consequently becomes immediately filled by odorous particles. In like manner, the closed sac has to get rid of odorous particles from within it by this same slow process of diffusion, before the odour ceases to be felt. From the nature of the stimulation and position of the end-organ, the limitations in time of the sensations are not well marked.

In the case of the sense of taste, the same holds true. Substances held in solution are alone tasted; the tongue is covered with a layer of mucin derived from mucous and salivary glands, and the nerves are not superficial but embedded in the epithelial covering. It will be easily understood, that in this case also, the accession of a sensation must, from the nature of the stimulus, and the position of the end-organ, be gradual in its production and slow in passing off, and therefore not strictly limited in time. The watery solution has to mix in the first place with the mucin covering the tongue before it can reach the end-organs situated in the epithelium.

In the case of hunger again, the limitations in time are due entirely to a condition of things other than mental. The fulness of the alimentary canal is associated with a feeling of comfort, and when no food is present therewith a feeling of hunger; and as there is every conceivable transition between a condition of full stomach and an empty one, so the passage of the one sensation into the other must pass through innumerable transition states.

If it be needed, another example may be mentioned in the case of the cold body applied to the horny tip of the finger, and to the thin skin covering the sides. The nerve-endings are stimulated by the addition or withdrawal of heat from the nerves of the skin. This is gradual, and does not correspond to the application of the cold body to the surface because of the horny epithelial covering. Where this covering is thin, the limitation in time of the sensation is more definite than where it is thick; and could we apply the cold body directly to the nerve end-organ, the limits would then be very sharply defined. Cover the hand with a glove, and the limits would be very ill-defined indeed.

Sufficient evidence has, I think, been adduced to show, that where the limits of a sensation are not well defined in time, we may conclude that this is not due to anything in the nature of the sensorium, but depends upon the way the external energy is changed into nerve energy in the terminal end-organ.

Let me define a sensation as the result of a transformation of the energy travelling along a nerve of sensation from without, into the energy manifested by the nerve cell to which it passes. We have, I insist, no reason to doubt that if that nerve energy travelled twenty times a second along a nerve of smell, of taste, hearing, or of sight, we should be conscious of twenty separate sensations in each case.

That such a transmission is impossible in every case we know, but it is due to the fact that in these cases the nerve cannot be stimulated from without so frequently.

In the case of the ear, the limits in time of high notes are sharper than those of the low notes, and probably this is due to a better damping apparatus in the ear. Could we increase the perfection of this damping, the limits of the consciousness in hearing would probably be sharpened almost indefinitely, for we must remember that the cause of the different sensations of sound is a difference of pitch, or periods of stimulation recurrent in time to which the sensorium is extremely sensitive.

If this be true, the period of time taken by a stimulus to produce a sensation depending upon the time taken by its energy to be transformed into nerve energy in the peripheral end-organ, will be some indication of the manner of this transformation. For instance, there is a very marked interval between the moment at which the rays of light strike the retina, and the production of the sensation; and further, the sensation remains for some time after withdrawal of the stimulus. It is unlikely, therefore, that the energy of light is directly transformed into nerve energy.

In shortly summing up the chief points alluded to in this paper, it may be stated—

(1) That stimuli applied to sensitive peripheral end-organs with increasing frequency, produce at first consciousness of the separate stimuli; then, their individual characters are lost, and a disagreeable sensation—"roughness" in the case of tactile feeling—is produced; and lastly, we feel a sensation indistinguishable from a constantly applied stimulus.

(2) For the development of nerve energy from external stimuli in a sensory nerve a latent period is necessary, and it elapses between the application of the stimulus and the resultant effect on the nerve. On withdrawing the stimulus, the nerve is still in a condition of activity, and remains so for a certain period (after-period). When this nervous energy is transformed into nerve-cell energy in the sensory centres, there is probably neither a well-marked latent nor an after-period.

(3) When, as in the sense of touch, the consciousness of the stimulus corresponds more exactly in time with the application of the stimulus than in the sense of sight, we are to look not to any differences in the limitation of consciousness itself, but to the time elapsing in each case before the nerve is excited by the stimulus and the length of the corresponding after-period.

2. The Old English Mile. By Wm. Flinders Petrie. Communicated by Professor Robertson Smith.

The length of the old English mile has been hitherto so uncertain, that any fresh light upon it is well worthy of study; and an important source of information—the map in the Bodleian Library—has not yet been brought to bear upon the question. The present inquiry was suggested by the sight of this map, which seems to add so much to our knowledge that a review of the whole subject has become desirable. It is proposed, therefore, in this paper to bring together all the data worth consideration, beginning with the most recent; and by deducing what the mean conclusion is from each source, to be thus able to compare together the various results, and so arrive at some definite statements within known limits of uncertainty.

The only discussion of the subject that has yet been made is that by Professor de Morgan * in the article "Mile," in the *Penny Cyclopædia;* in other encyclopædias no notice is taken of the history of the English mile, and D'Anville makes only a rough deduction as to the old mile being longer than the statute mile; he uses but few data, complicates these with unproved theories, and is somewhat vague in his statements. †

It will be necessary first to briefly mention some of the conclusions in De Morgan's most valuable article in order to point out their bearing on the inquiry. In beginning the article he seems strongly inclined to disbelieve in the existence of any old mile longer than the statute mile, mainly relying on the fact of Bernard (1688) and Greaves (1647) not describing any longer mile. He says, "on the authority of the silence of Bernard and Greaves above referred to, we must remain of a contrary opinion (*i.e.*, to D'Anville), and must suppose that the computed miles preserved by Ogilby (1675) had been intended to represent the number of statute miles, but erroneously given. What then may these computed miles mean which had served the common purpose in the estimation of distances? The word computed never meant reputed, but was always applied to a result of reckoning of some kind or other." Now it so happens that, in the *Traveller's Guide* (1699) ‡ (a typographical edition of Ogilby's Atlas), these miles are variously described as "computed," "vulgar computation," and "reputed;" so that the objection raised by De Morgan to their being those in common repute and use is not borne out by the name employed. He notices Ogilby's guess that the computed distances read a less number by omitting the lengths of the towns; and, rejecting that idea as an insufficient explanation (as it certainly is), he concludes that the "computed" distances were derived from the straight-line measurements of statute miles from a map, thus omitting the length of windings of the roads. But this explanation also is quite insufficient, as, in the first place, the windings will not account for even as much as half of the difference of numbers of computed or reputed and statute miles; secondly, the difference between computed and statute miles exists just as plainly on the straight Roman roads, where no windings exist, as on the winding roads; and finally, as we shall see, these computed miles are the same as those in use in the thirteenth century, when maps were very scarce, and it is quite unlikely that the populace should have adopted their current reckoning of every-day journeys from the measurements of a few distorted monastic manuscripts. Hence, De Morgan's explanation is certainly insufficient; and in the latter part of his article he argues for an old mile equal to 1½ statute miles, concluding thus: "We think it by no means improbable that 100 ancient miles are as much as 150 statute miles, and tolerably certain that they exceeded 145 such miles." Thus he agrees with Sir Henry Ellis, who writes, "the ordinary mile of England . . . . . was nearly a mile and a half of the present standard."*

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* *Notes and Queries*, i. xii. 195.

† As when he describes 15·2 miles as being "quelque chose de plus que 14," in *Mésures Itineraires*, chap. x.

‡ De Morgan does not seem to have seen this book at all, as he refers to *The Complete Tradesman*, by N. H. (1684), as giving the lists of computed and measured miles, which this edition of Ogilby gives far more completely.

A point on which De Morgan lays much stress is the shortening of the roads in modern times, and the much greater length he supposes them to have formerly been. The only evidence adduced is a comparison of four of the distances by Ogilby (1675) in statute miles with modern statements of the same, which may not have followed exactly the same route. But on measuring the modern distances† of about ninety of Ogilby's statements, there does not appear to be any constant difference between his reckoning and the present roads; and in single lengths Ogilby was certainly in error occasionally, since he sometimes gives a *less* distance than the shortest practicable line.‡ From a general consideration of the history of roads, and the manifestly ancient course of most of them, it seems very unlikely that any notable alteration has taken place in their length since they were the first tracks through waste lands.

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* *Introduction to Domesday Book* (1833), i. 145 *et seq.*

† The actual distances in statute miles are here ascertained from the county maps of *The National Gazeteer* (1865 ?); these are very clear, and appear to be accurate on comparison with the Ordnance Survey. The windings of the roads are in all cases carefully attended to in the measurement.

‡ *E.g.*, High Wycombe to Tetsworth, 12·0 Ogilby, =13·6 miles really; Prestein to Rhyadergowy, 12·7 Ogilby, =14·4, or more, really; Royston to Huntingdon, 19·2 Ogilby, =21·4, or more, really.

After what has been remarked above, there does not seem any reason for not taking the statements of distances in various books and maps to be what they profess to be, that is, the "reputed" or "vulgar" long miles between the places in question, reckoned exactly like the statements of the same distances in statute miles.

It may seem rather astonishing to see in all maps, until within recent years, such a careful definition of miles as "statute miles, 69½ to 1°"; but the need for this explicitness arose from the great confusion which existed between different miles. In Gibson's edition of *Camden* (1695) there are no less than three mile scales on nearly all the maps; these scales vary a good deal, but by measuring each of them, and a distance between two places on each map to give the true scale, the values of the three miles, "great," "middle," and "small," may be deduced.* On thus obtaining a value from each of the forty or more maps, and taking the mean result for each sort of mile, we find the miles to be respectively 1290 ± 16, 1167 ± 14, and 1037 ± 11 thousandths of the statute mile.† Now these values are very exactly in the proportion of 10, 9, and 8;‡ and since we cannot doubt but that 1037 was intended for the statute mile of 8 furlongs, it seems that these three miles were of 10, 9, and 8 furlongs respectively.

Next before this there is the great authority of Ogilby, the surveyor of England, to whom the first accurate road maps and measurements are due. He published his atlas, *Itinerarium Angliæ*, in 1675, stating the miles of "horizontal distance" (*i.e.*, as the crow flies), of "vulgar computation" (*i.e.*, the old long miles), and of "dimensuration" (*i.e.*, the statute miles measured by his perambulator); but as he only gives the totals in this way, the details must be sought in the typographical edition of his work called *The Traveller's Guide* (1699).* For comparing the "computation," "vulgar computation," or "reputed" miles, with the real distances, Ogilby's statute miles have been here adopted, as he has no constant error in one direction, and his fluctuating errors are much less than those of the reputed miles, so that no further inaccuracy will be caused by taking his statement. In this investigation the roads were broken up into lengths of about forty miles each for purposes of comparison of the mile lengths; and besides this, there are shorter lengths of cross roads. The lengths compared together are in all 154 in number, of which 134 belong to the old mile, eight to the N.W. mile, and twelve to the Welsh mile. From the mean of these 134 lengths, the old mile appears as 1307 ± 5. The local miles we pass over for the present; but the posting miles which are given, though agreeing in general with the old miles, yet in nine cases are shorter, and in two cases a little longer; the shortest form is equal to the statute mile.

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* The degrees on the borders of the maps cannot be trusted, as they bear no fixed relation to the miles, and the longitudes of the western counties are very erroneous.

† Throughout this paper all miles will be thus stated in thousandths of the statute mile.

‡ Thus, $1290 \div 10 = 129{\cdot}0 \pm 1{\cdot}6$.
$1167 \div 9 = 129{\cdot}7 \pm 1{\cdot}5$
$1037 \div 8 = 129{\cdot}6 \pm 1{\cdot}4$.

From Ogilby's work lists of miles were reprinted more or less abbreviated, as in the *The Complete Tradesman*, by N. H. (1684), which gives both "computed" and "measured" miles. In *The Exact Dealer*, by J. H. [John Hill] (1688), the miles are generally the reputed or long miles of Ogilby, but sometimes the post miles, or others. In *The Description and Use of two Arithmetick Instruments*, by Sir Samuel Morland (1673), just before Ogilby's publication, the miles are the same as the post miles in Ogilby, where they differ occasionally from Ogilby's reputed miles.

The next earlier information is in the maps of England commonly known as "The Quartermaster's Map" (1644). This gives a scale on each of the six sheets; and on measuring two distances on each sheet to obtain the absolute value, it appears that these maps are far more accurate than any others of that period, the average error being but a third of that of Saxton, Speed, or Gibson. The mile value from this source averages 1255 ± 10.

In the year before this *A Direction for the English Traveller*

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* This is catalogued under Ogilby in Brit. Mus.; but he died in 1676. There is no editor's name to it.

(1643)* first appeared; this consists of a series of small copper-plate maps of each county with a cross-line table of the distances between places in the county, besides a similar plate of all England. The same plates were printed from again by the same publisher in *A Book of the Names of all Parishes*, &c. (1662 and 1668). Taking from each plate two of the distances stated between places in miles, and comparing the 73 distances thus extracted with the true road distances, the mean mile is 1375 ± 12. But this is so decidedly longer than the mean mile of any other authority, that it seems as if these distances had been compiled and tabulated by measurement from the plates, or from some older maps, in straight lines. If this were the case we should subtract about 7 per cent.,† and the true mile will then be 1280 ± 20, and thus in accordance with other authorities.

Speed's maps of counties preceded this by some time (1610); and on measuring the mile scale, and a distance between towns, on each plate, and then taking the mean of the 43 results, the mile comes out 1300 ± 12, omitting the Welsh counties.

Saxton's county maps (1575) also have scales, and were examined like Speed's for extracting the mile. From thirty plates the mean result is 1310 ± 16, omitting the Welsh as before.

William of Worcester (1473) gives measurements and distances continually, throughout his rambling note-book; and by extracting all the distances, his mean mile may be obtained. But it is not desirable to include any of less than 5 miles, as such are necessarily much less accurate, being only stated to single miles; and all sea distances, and rough statements of the dimensions of districts or countries, should be omitted. There then remain 92 distances, and on measuring all these on modern maps, it appears that his mile was 1310 ± 20.

Sir Gilbert de Lannoy's distances in Palestine (1422), quoted by De Morgan (article "Mile"), give by five examples a mean mile of 1180 ± 20, *plus* about 8 per cent. for winding of roads, and therefore probably about 1280 ± 20.

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* Published by Thos. Jenner, under whose name it is catalogued in the Brit. Mus.

† By careful map-measurement of six long distances in England of 50 to 200 miles each, the excess due to windings is 127 on the 1000; and on short distances, of 12 to 25 miles, the windings make an increase of 66 on the 1000, beyond the direct distances in straight lines.

Roger Bacon's distances in Palestine (1253), also quoted by De Morgan, give by fifteen examples, a *leuca* equal to 2 miles of 1230 ± 60,* *plus* about 7 per cent. for windings, = 1320 ± 60. Neither this nor the previous statement are worth much, as they depend on the estimates of a few foreigners in a strange country, and not on the well-known reckoning of places where the writers and all their acquaintance had always lived, as in England.

We now come to what is the oldest authority, and also one of the most complete. This is the vellum map of England, Wales, and Scotland, in the Bodleian Library, which has the roads and distances marked on it throughout England and Wales. This map is attributed to the thirteenth century, and is by far the finest map known for such an early period. It is written in red with brown lines, and with the sea coloured green; and it is in very fair condition. It was published in copper-plate facsimile by Basine, with a partial description by Gough (to whom it belonged) in *British Topography*, i. 76† (1780). It has also been published in coloured facsimile, with a key-plate of the names printed, in *National Monuments of Scotland*, part iii., edited by C. Innes. Basine omitted things altogether when he could not easily read them, and his renderings often differ from Gough's account. Generally his map has a better reading than Gough's text; but they both have many errors.‡ Gough continually omitted the numerals, even when Basine read them rightly; and he made curious mistakes in the places.§ Of course, no attempt was made to utilise the distance in such a manner of treatment. The facsimile by C. Innes is a fine piece of work, and apparently very correct; but the names are often omitted from the key-plate if hard to read; no attempt is made to supply lost names, by considering the positions of places; and the words have been merely read, as well as might be, without a reference to a modern map to check the reading.‖ The main attention of the editor was given (very properly in such a work) to the Scotch topography, and the far more valuable part of the map —as a map—was treated as an annex of little importance to the subject in hand. No attempt to transcribe or examine the mile distances was made either by Innes or by Gough.

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* There is a manifest mistake in the place names; they should read Joppa to Cæsarea, Cæsarea to Aco, &c.

† The map in the Brit. Mus. copy is wrongly bound in at vol. ii. p. 76.

‡ For errors in common, see Colebrook to Maidenhead, x. in Gough and Basine, but vii. in Innes, which is the true reading by the distance; Whitby to Guisborough, xii. Basine, xiii. Gough, but xvii. Innes, the true reading.

§ *E.g.*, applying "Burgh" to Carlisle, while it belongs to a separate town on the map.

‖ Thus there is the curious transcription of Coxton for Tuxford, of Lenning

When I saw this map at Oxford, and transcribed as well as I could * in an hour or two the lists of distances, it seemed very evident that all the distances in the south and east of England had been rewritten by some hand well accustomed to mediæval script; and this accounts for the ends of many words going off into a mere series of strokes, since the rewriter was not certain of part of the name, and just inked over what he could see. This rewriting deserves careful study in considering the map; and as it was apparently done before the sixteenth century, and the old writing must have been fading then, and yet is not illegible in parts even now, it is some evidence as to the great age of the map. What is now much needed is a critical examination of this map, identifying all the places by comparison with modern maps, and recovering any traces of the first writing of names and distances where it has become all but illegible. This work needs a good palæographer; but for the question of the miles, which is what we have at present to consider, such care is not required; for, if a few doubtful distances are omitted, it will not perceptibly affect our results. From a comparison of the readings of Basine, Gough, Innes, and my own notes, the distances may be pretty safely settled in all legible cases; and after omitting those in Wales and Cheshire, which show a different mile, there are 130 distances available for examination. The mean value of the old mile from these is 1265 ± 9.

Having now described the various data available for fixing the old mile, we will place the results all together and compare them, in terms of thousandths of the statute mile; stating the mean result from each source, the probable error (±, *i.e.*, what amount of variation the truth is as likely to exceed as to lie within), and the average error of a single length, which shows the relative accuracy of the different sources.

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for Leeming, and the placing of Abergavenny on the west coast of Wales for a town which must be Aberdovy.

* The map is framed and glazed, and screwed high up against a pillar in a poor light; hence it is not easy to study.

A.D.			Mean mile.	Mean error.
1695	Gibson's maps,. . .	40 maps,	1290 ± 16	110
1675	Ogilby's numbers,.	134 distances,	1307 ± 5	65
1644	Quartermaster's map,	11 distances,	1255 ± 10	35
1643	Jenner's numbers, .	73 distances,	(1375 ± 12)	110
	or allowing for windings, probably		1280 ± 20	
1610	Speed's maps, . . .	43 maps,	1300 ± 12	90
1575	Saxton's maps, . .	30 maps,	1310 ± 16	100
1473	Wm. Worcester's notes,	92 distances,	1310 ± 20	200
1422	Lannoy's account, .	5 distances,	1280 ± 20	60
1253	Roger Bacon's account,	15 distances,	1320 ± 60	480
1250?	Bodleian map, .	130 distances,	1265 ± 9	120

The question now before us is, what probability is there of any change in the popular mile during the four centuries in which we have traced it? The possibility of change certainly lies within narrow limits, since (looking to the accurate authorities) the later examples cannot be taken to exceed 1307, nor the earlier to fall short of 1265.* Now, it is very unlikely that the Bodleian mile was as long as 1300, in fact it is more than 100 to 1 against its being so; therefore, the oldest form cannot be taken as a mere careless variant of Ogilby's value of 1307. Bacon, Lannoy, and William of Worcester are all too uncertain to decide on the difference in question. Coming down to the seventeenth century, the Quartermaster's maps, which agree very well among themselves, corroborate the earlier value, but we can hardly set them up against the large mass of information in Ogilby's tables.

On the whole, I should incline to fix the value of the old English mile at 1300 ± 10 during the end of the fifteenth and on to the seventeenth centuries, and to suppose that during the fourteenth century and the beginning of the fifteenth, it was lengthening from a value of 1265 ± 10, which it had in the thirteenth century. As it had lengthened thus, it is not improbable that the original value of it was still shorter, perhaps not exceeding 1250, or 1¼ statute miles. In any case the range of uncertainty is now reduced to very narrow limits, compared with the vague conclusions that have been hitherto adopted.

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* The mile in Italy having lengthened 1 per cent., though many of the old Roman milestones remained standing in the country, shows in which direction itinerary measures are likely to change.

We will now briefly notice the miles of the N.W. counties and of Wales. That a longer mile was in use in Lancashire, Cheshire, and Shropshire is certain both from the various authorities that we have just discussed agreeing in it, and also from the fact of a longer perch surviving in those parts.* On taking out the distances in Cheshire and Shropshire, they yield the following mile:—

Bodleian.	Wm. Worcester.	Saxton.
1540 ± 100	1570 ± 70	1420 ± 10
Speed.	**Ogilby.**	**Gibson.**
1340 ± 50	1400 ± 15	1385 ± 60

Lancashire is 1400 in Saxton, but comes down to the usual old mile in Speed and Ogilby. Thus it seems that the old N.W. mile was about 1560 ± 80, and was somewhat assimilated, as time went on, to the usual old mile of England, 1300 ± 10. There are not sufficient accurate data to allow of a complete disentanglement of local miles; but the Bodleian map distances in the eastern counties are not over the average, while later on they are higher. The southern and S.W. counties generally have a lower mile than the northern. But there is nothing necessarily to show more than accidental variation in the unit, except in the N.W. counties, considered above, and in Wales, which we will now notice. The Welsh distances give mile values of—

Bodleian.	Saxton.	Speed.	Ogilby.	Gibson.
1465 ± 45	1410 ± 20	1360 ± 20	1383 ± 20	No great mile.

Here there appears to have been an old mile of about 1460 ± 50, probably identical with the Cheshire mile; and, like that, gradually approximating to the usual old English standard.

The origin of the old English mile, which we have seen to be 1·265 statute miles, now remains to be considered.

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* Lancashire perch 7½ yards, therefore mile = 1·360 statute miles.
Cheshire ,, 8 ,, ,, = 1·460 ,,
—*Notes and Queries*, vi. i. 264.
Herefordshire perch 7 yards, therefore mile = 1·270 statute miles.
Staffordshire ,, 8 ,, ,, = 1·460 ,,
—*Ency. Brit.*, 3d edit., art. "Perch."

First we must note that the statute mile and furlong were probably independent of each other originally. The earliest mile near the statute mile was one of 5000 feet, defined as $7\frac{1}{2}$ furlongs 3 perches and 2 palms,* about 1350 AD. Then about 1470 A.D. a mile appears of 8 furlongs,* which first received legal recognition in 1593 A.D.† Now, if the mile of 8 furlongs had always existed, it is very unlikely that one containing a fractional number of furlongs would have arisen, so that it is probable that the furlong is the older measure, and that the mile was adapted to fit it. And this is also indicated by the register of Battle Abbey mentioning furlongs but not miles; so that the furlong appears a long time before the mile of 8 furlongs.

The furlong, though now defined by the yard standard, was originally independent of the present foot and yard; for it is impossible to suppose a length of $5\frac{1}{2}$ yards being selected without any reason. This is manifestly the nearest translation into the lesser standards of a measure which was originally incommensurable with them.

Thus it seems most likely (as De Morgan supposes) that the statute mile was originally 5000 feet of 12 inches, and that it was modified to 5280 feet in order to agree with the furlong, with which—as being the nearest measure in size, and the basis of land measurement—it was most required to accord. And the furlong was an independent unit, not having any exact relation to the foot of 12 inches, or the mile of 5000 feet.

Now we have seen by Gibson's maps that the long mile was evidently reckoned as 10 furlongs, being exactly $\frac{10}{8}$ of the statute mile there; and we have seen that the old mile was originally $1{\cdot}265 \pm 10$ statute miles, or even slightly less. The furlong, then, would be $\cdot 1265$ statute mile, $= 8015 \pm 64$ inches, or rather less. The chain, or $\frac{1}{10}$ of the furlong, would be $801{\cdot}5 \pm 6$ inches. Below $\frac{1}{4}$ of a chain, or a perch, we lose sight of the original subdivisions, as the link is a modern invention of land surveyors, and the $5\frac{1}{2}$ yards is merely an approximate adaptation of a different standard.

Turning now to other countries, we meet at once with a mile closely similar to the old English mile; this is the old French mile, which is equal to 1·21 statute miles, or within 3 per cent. of what we have seen to be probably the earliest English mile. And this resemblance is not only in length, but also in subdivision, as the French mile is 1000 toises, and this is decimally divided like the 10 furlongs in the mile, and the 10 chains in the furlong. Also, the English league consisted of two old English miles,* like the French league.

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* Canterbury registers, fourteenth century, quoted by De Morgan, art. "League," *Penny Cyclopædia.*

† De Morgan, in art. "Mile."

This continued decimal division of the French mile suggests that perhaps the old English mile may have had lesser subdivisions than the chain; $\frac{1}{10}$ of the chain would be 80·15 ± ·6 inches; and if this fathom was subdivided into 6 feet, like the French toise, we should have a foot of 13·36 ± ·1 inches, or rather less perhaps by the original mile.

Now, on referring to *Inductive Metrology*, p. 107, it will be seen that the commonest foot known in the mediæval remains in England is 13·22 ± ·01 inches in length; this being more commonly found even than our modern foot of 12·0 inches. Here then we have found the basis of the old mile appearing quite independently as the most frequent measure in mediæval England. This foot appears to be the same as the classical "Drusian foot," which may have been introduced by the Romans into both France and England.

The series of measures thus connected with the old English mile run thus:—

	Inches (by the mile).			Inches (by the foot).	
Foot . . .	13·36± ·1		or	13·22± ·01	
6 feet=1 fathom .	80·15± ·6			79·32± ·06	
10 fathoms=1 chain .	801·5 ± 6·	statute miles.		793·2 ± ·6	statute miles.
10 chains=1 furlong	8015· ± 60·	= ·1265±·001		7932· ± 6·	= ·1252±·0001.
10 furlongs=1 mile	80150· ± 600·	=1·265 ±·01		79320· ± 60·	=1·252 ±·001.

The second determination, working from the foot, which is far more accurately known than the mile, is probably the most trustworthy; and as we have observed that the original form of the mile was probably rather shorter than 1·265, therefore this restoration of the old mile from the foot, shown by various buildings, represents the data that we have as well as anything can, and is far more accurate than anything that we can hope to recover from itinerary measures.

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* See Roger Bacon's distances, before quoted.

We see, then, that by the exclusive survival of the 12-inch foot, we have lost the basis of a decimal system of measures, and thus, complicated our land measure in a most troublesome manner.

In this examination, then, we have traced the old English mile back through four centuries, and seen that it varied but little in different times, and as used by different persons. And, following the analogy of the old French mile (with which it seems to have been identical), we see that it was part of the decimal system of the fathom, chain, furlong, and mile, based upon the most usual mediæval foot of England. Whether this mile was introduced by the Normans, or whether its basis had remained in England (like other measures) from Roman times, is still unsettled; and this question, as well as the local variations of the mile, and the origin of the miles of Wales and Cheshire, must remain for future discussion, when other and more complete materials may be discovered.

3. A Re-Statement of the Cell Theory, with Applications to the Morphology, Classification, and Physiology of Protists, Plants, and Animals. Together with an Hypothesis of Cell-Structure, and an Hypothesis of Contractility.* By Patrick Geddes. Plate IV.

Position and Importance of the Cell Theory in Morphology.—Vast though is the literature of vegetable and animal morphology, it becomes more readily grasped than that perhaps of any other science, when we classify it in relation to the few great works which initiated and for ever mark the successive waves of advance. Thus of the early pre-morphological or encyclopædic stage, when materials were being little more than heaped together, the works of Pliny or Gesner may be taken as types, to which the other encyclopædias of Natural History by Jonston, &c., furnish at first mere supplements. The *Systema Naturæ* of Linnæus closes the old and marks a new era, and initiates that systematic enumeration of the flora and fauna of the globe which has since made such vast progress. All subsequent systematic literature, no matter how important, no matter how much exceeding in quantity of new forms, involves no essential, no qualitative advance: thus the greater part of the proceedings of such

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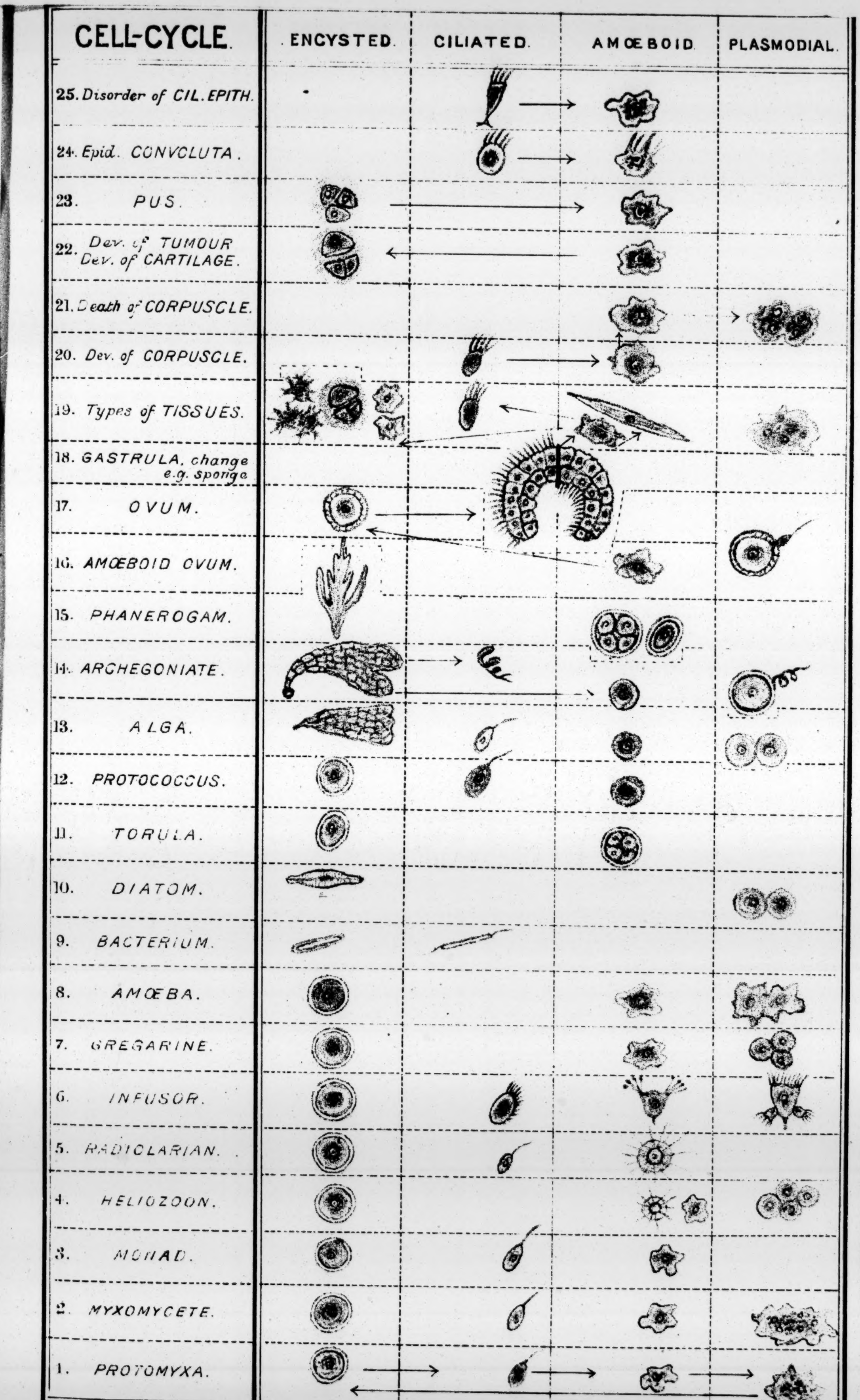
* Prelim. Note in *Zool. Anzeiger*, No. 146, 1883.



CELL-CYCLE.	ENCYSTED.	CILIATED.	AMŒBOID.	PLASMODIAL.
25. *Disorder of* CIL. EPITH.				
24. *Epid.* CONVOLUTA.				
23. PUS.				
22. *Dev. of* TUMOUR *Dev. of* CARTILAGE.				
21. *Death of* CORPUSCLE.				
20. *Dev. of* CORPUSCLE.				
19. *Types of* TISSUES.				
18. GASTRULA. *change e.g. sponge*				
17. OVUM.				
16. AMŒBOID OVUM.				
15. PHANEROGAM.				
14. ARCHEGONIATE.				
13. ALGA.				
12. PROTOCOCCUS.				
11. TORULA.				
10. DIATOM.				
9. BACTERIUM.				
8. AMŒBA.				
7. GREGARINE.				
6. INFUSOR.				
5. RADIOLARIAN.				
4. HELIOZOON.				
3. MONAD.				
2. MYXOMYCETE.				
1. PROTOMYXA.				

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Societies as the Zoological or the Linnean, such new and important faunistic literature as that contained in the magnificent volumes of the "Challenger" Expedition, or even the greatest systematic works, find their highest place not as superseding, but as supplementing the fundamental classic of Linnæus. Similarly all works of detailed anatomical research united with exact comparison and clear generalisation, are in botany simply to be regarded as supplementary to the little work in which Antoine de Jussieu founded the Natural System, or in zoology to the *Règne Animal* of Cuvier, himself also an intellectual heir of Vesalius. Embryological literature in like manner finds its place in the appendix and commentary to the works of Robert Brown or Von Baer respectively; at the head of all investigations of serial homologies stands Goethe's memorable essay *On the Metamorphoses of Plants;* while all evolutionary literature may be arranged round the works of Lamarck and Darwin. The morphological investigator, unless claiming to initiate some new line of thought, has thus to take his place simply as an assistant to one or more of a few immortal masters.

But the cell theory? This is apt to be excluded from general morphology altogether, and to have a separate subordinate province —of histology—erected for it, a vicious tendency, which although by no means fully adopted, still somewhat injures the continuity of treatment in the writer's recent essay on Morphology.* To ascertain its position, we must first briefly glance at its history.

Here the fundamental classic is undoubtedly the *Anatomie Générale* of Bichât, though in this the name of cell does not even occur, the "tissue" being assumed as fundamental. The analysis of the organism into definite structural components is, however, the main idea; after this the history of histology is little more than of accumulating observations with improving optical and technical appliances, until we come to Schleiden, who boldly referred all vegetable tissues to the cellular type, and the plant embryo to a single nucleated cell; while Schwann, by immediately extending the generalisation to the animal world, fully constituted the cell theory. This idea then is fundamental in morphology; for the innumerable species and genera of plants and animals made known under the leadership of Linnæus, and the numberless anatomical resemblances and differences investigated by Cuvier and his disciples, become reduced to resemblances and differences in the details of structure and position of fundamentally similar unit masses; while the resemblances of development made known by embryologists become the connecting link between the cell theory and these generalisations of adult structure. It is not necessary to do more than merely allude to such applications of the cell theory, or to that of the study of pathological structure initiated by Goodsir and Virchow, or to that brilliant confirmation of the unity of the animal and vegetable cell which has lately been afforded by the detailed study of the processes of cell multiplication. Agassiz* was fully justified in the opinion that the most brilliant result of modern science was the ovum-theory, and thus it is beyond dispute that "in our own day, as in those of Bichât and Schwann, the labours of the histologist, when inspired by higher aims than that of the mere multiplication of descriptive detail, are of supreme morphological importance, and result in the demonstration of a unity of organic structure deeper even than any which we owe to Linnæus or Cuvier, Goethe or Geoffroy." †

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* *Ency. Brit.*, xvi. p. 837; amended in German translation, *Jenaische Zeitschr.*, 1884.

Cell.—The position and importance of the cell theory being thus defined, the fundamental necessity for a precise conception of the cell itself will be sufficiently obvious. The early progress of this is well known; at first the vegetable cell-wall gave the type, while Schwann's cells were essentially nucleated vesicles with fluid contents. Dujardin described the "sarcode" of Foraminifera; Von Mohl discovered the "protoplasm" of the vegetable cell; while Max Schultze identified both as the same substance; showed it, and not the membrane to be essential; and gave an amended definition of the cell as a unit mass of nucleated protoplasm. For working purposes it is this conception which is generally accepted, and almost every dissertation or treatise upon the general questions of botany or zoology, histology or physiology, commences by postulating it, the amœba being most frequently taken as the standard type.‡

Unsolved Problems.—Such a conception of the fundamental cellular unit, however valuable, yet throws no light upon a large number of problems at present under dispute; and it is the aim of the present paper to draw attention to some of these, and by the aid of a re-statement of the cell theory (a new appendix as it were to the *Anatomie Génèrale*, or to the work of Schwann), to propose a solution of them.

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* *Essay on Classification.*

† "Morphology," *Ency. Brit.*, xvi. sec. 3, p. 840.

‡ Of this no better instance can be afforded than the introduction to the admirable *Manual of Physiology* of Dr Michael Foster.

The problems then which it is proposed to discuss may be briefly enumerated for convenience under separate heads, as follows:—

(1) The classification and affinities of the Protozoa.

(2) The classification and affinities of the Protophytes.

(3) The systematic position of the Myxomycetes and other peculiar forms.

(4) The acceptance or rejection of Hæckel's third intermediate sub-kingdom *Protista*.

(5) The phylogeny of the lower plants and animals, and their origin from one or several stocks.

(6) The relation of the Protophytes to the higher plants.

(7) The relation of the Protozoa to the higher animals.

(8) The morphological relations of plants to animals and their origin from a common stock, or from separate ones.

(9) The classification of animal tissues.

(10) The physiological rationale of changes of cell-form.

(11) A theory of the origin of sexual reproduction, and its relation to conjugation and other cases of cell union.

(12) The relation between normal and pathological tissues.

(13) The influence of the environment on the origin of organic forms.

(14) A theory of cellular variation (since the theory of descent involves a theory of variation, and all variations, normal and pathological alike) must ultimately be expressible in terms of cellular ones.

1. *Classification and Affinities of the Protozoa.*—The Protozoa have long been thrown into a few main groups, of which the *Rhizopoda*, embracing all essentially amœboid forms like the Protoplasta, Foraminifera, Heliozoa, and Radiolaria, and the Infusoria, including all those of permanent and usually ciliated type, are the oldest and most important. The position of the Gregarinida, of the Monads, and still more of forms like *Chlamydomyxa* and the Labyrinthulida,

or Hæckel's *Protomyxa*, is still disputed, nor is that of Rhizopods to Infusors, despite their more or less intermediate forms, as yet settled.

But our current conceptions of the groups of Protista are based upon their more prominent and permanent characters only. An infusorian is constantly thought of as a permanently ciliated or flagellate organism; a radiolarian is constantly described as a highly differentiated rhizopod, with two layers of protoplasm, a gelatinous envelope, yellow cells, and siliceous skeleton; or again its simpler ally the heliozoon is seldom or never thought of without its radiating pseudopodia with their peculiar axial filaments.

Yet such conceptions involve a morphological fallacy of the most serious kind. These are indeed the most highly differentiated, the most frequent, the most permanent, and therefore the most striking forms in which these organisms are known to us, but of late years it has been becoming more and more obvious that each of these well-known forms is at best but the most important stage of a life-history, during which the organism passes through one or more other phases of form, which may indeed be transitory, but thereby lose no whit of their morphological distinctness or importance.

Thus, thanks to the researches of Dallinger and Drysdale, Butschli, Savile Kent, and others,* we know that a monad is not a permanently flagellate form, but appears at one time encysted, at another becomes amœboid; the ciliated embryos of the Acinetæ have long been known,† while more recent investigations have established the multiplication of radiolarians by zoopores,‡ or the frequent union of several individuals of various species of Heliozoa§ or of Gregarines|| into a single mass. In short, the progress of recent research among these forms has largely lain in revealing the existence in even the most highly differentiated forms of a life-cycle of several distinct phases.

In lower forms more attention is paid to the whole life-cycle, yet not sufficiently so. The Amœba is still constantly spoken of as if its encysted stage were of no morphological interest, whereas no permanently amœboid form has ever been proved by continuous

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* Savile Kent, *Manual of the Infusoria.* † *Ibid.*

‡ Brandt, *Monatsb. d. Berlin Akad.*, 1881.

§ Gruber, *Zool. Anzeiger*, No. 118, 1882.

|| Gabriel, "Z. Classif. d. Gregarinen," *Zool. Anzeiger*, 1880.

observation to exist; in the Gregarine, on the other hand, the amœboid state is often practically ignored by classifiers.

In the remarkable Protomyxa of Hæckel, however, we have an organism in which several phases of form are almost equally prominent, so that its description as an amœboid, or a ciliated or as an encysted organism, has been alike impossible. For here is no permanent highly differentiated form; but an eventful life-history in which one protean mass of protoplasm passes through a cycle of several distinct phases. Let us carefully examine then these phases, since light may thus be thrown upon the life-histories of the higher Protozoa already referred to.

Starting then from the encysted stage, in which a mass of protoplasm is surrounded by a dense envelope, we find that from this after a time (in which division of the protoplasm has in this case occurred), there issues a swarm of somewhat pear-shaped, naked, motile, flagellate organisms. After a brief period of active locomotion, these lose their flagellum and their permanent form alike, extrude pseudopodia, in short, melt down into amœbæ. After some period of amœboid life they flow together into a single protoplasmic mass—unite into a plasmodium, as it is termed, and this after another brief but remarkable period of locomotion and pseudopodial activity, settles down into a spheroidal mass; this re-encysts itself, and the whole cycle commences anew (Plate IV. fig. 1).

If now we make a diagrammatic representation of this life-history (or rather *form-history*, as it should more accurately be termed), of *Protomyxa*, exhibiting (1) the encysted, (2) the ciliated, (3) the amœboid, and (4) the plasmodial stages, we shall find that all those temporary phases of form observed among the higher Protozoa may at once be referred to one or other of these (figs. 3, 8). If this be so, those curious phenomena of the exhibition of ciliated forms by organisms usually of amœboid type like the Radiolarians, or of amœboid forms by organisms almost permanently encysted or motile, like Gregarines or Monads respectively, lose their anomaly, and come under a generalisation at once simple and comprehensive, viz., that a form-history essentially similar to that of *Protomyxa* (with blanks it is true, but blanks which the progress of discovery is constantly filling up, and may not unlikely almost wholly fill), may be sketched out for all the higher Protozoa. The same idea may be better expressed in the statement that the higher Protozoa may be regarded as organisms of fundamentally Protomyxoid form-history, in which, however, some one phase has attained comparatively high specialisation and differentiation, together with relatively greater permanence. Or the same idea may be stated in the exactly converse way, that the Protozoa may be viewed as organisms of fundamentally Protomyxoid form-history, in which, however, one, two, or three of the phases become abbreviated into merely embryonic ones, or may even (by that shortening of development with which embryologists are so familiar in the higher organism) become completely suppressed.

Thus then, if illustration be needed, a Heliozoon differs from Protomyxa merely * in the higher differentiation and relative permanence of the amœboid phase of its life-cycle, since more or less brief encysted, ciliated, and plasmodial phases have all been observed. The more specialised but kindred Radiolarian seems to have lost its plasmodial phase; so too, perhaps, has the monad, while in the Gregarine only the ciliated state is wanting.

2. *Affinities of the Protophyta.*—Passing now to the second problem proposed at the outset, that of the affinities of the Protophytes, the same conception may be at once applied. Too much importance is here attached to the encysted phase, for the life-cycle is clearly apparent in many forms. Treviranus, in 1811, made the notable discovery that the spores of Confervæ move like Infusoria.† Many years later Unger described the same phenomena in *Vaucheria clavata*, as "the plant in the moment of transition to the animal,"‡ while Von Siebold and others argued against this essentially just view, with more ingenuity than soundness. The wide prevalence of this change is constantly being confirmed. Not only have we a thoroughly well-defined and constant cycle between the resting and the ciliated state, but we may fairly reckon the brief phase of inactivity, which so often is observable between the loss of cilia and the return to the encysted state (when the organism closely resembles

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* The possession or non-possession of a nucleus is of course immaterial, so far as the form-history is concerned.

† Treviranus, *Beitr. z. Pfl. Physiol.*, Gött. 1811, p. 78.

‡ Unger, *Die Pflanze in Momente d. Thierwendung*, Wien, 1843. Siebold, *Dissert. de finibus int. reg. an. et reg. constit.*, Erlangen, 1844.

a contracted amœba), as representing the amœboid form. A distinct assumption of the amœboid state at the close of the ciliated one, is sometimes to be observed,—as lately by Reinke* in Bangia. And thus the cycle is complete, save only for the plasmodial phase.

The importance of this view for the Protophytes then, is scarcely less than for the Protozoa. With a tendency of the encysted state to predominance, more marked even than in the Gregarines, the other phases are by no means obliterated, and we thus—and only thus—obtain an intelligible explanation of that alternation between the resting and the motile phase which is so frequent and so characteristic. The inevitable applicability of this to classification, and the light it yields, will be sufficiently obvious. Without prematurely proposing a detailed classification, it will be obvious that we must regard those forms, which like *Torula*, exhibit only the resting state, not as primitive, but as exceedingly specialised, and those which exhibit more and more of the cycle as less so.

3. *Affinities of the Myxomycetes.*—Passing to the *Myxomycetes*, it will at once be evident, that unless the present theory can be entirely overturned, they have no place among the fungi proper—where it is the encysted phase that predominates, the others being greatly reduced or suppressed; but are in fact morphologically as remote from these as are the monads. The Myxomycetes must be placed next *Protomyxa*; in fact, *Protomyxa* is simply the least differentiated known Myxomycete. Their higher forms are interesting—first, in very frequently showing less of the ciliated stage, and secondly (a more important character, since here they are unique among living beings), in affording an enormous differentiation of their plasmodial stage; the complicated forms which many of them exhibit being simply those of their plasmodial froth, to which permanent shape is then given by the formation of a cellulose envelope. The resemblance to fungi is thus as purely superficial and adaptive as that, for instance, of Hydroids to Polyzoa, and, like it, is of physiological interest alone.

4. *The "Protista."*—The general non-adoption of Hæckel's proposal of a third intermediate *Regnum Protisticum*, has been due to three main reasons,—of which the first is that the proposal seems only to double the difficulty, since it does not enable us to distinguish

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* *Mittheil. d. Zool. Stat. in Neapel.*, 1883.

Protista from animals on the one hand, or plants on the other; the second, closely related to the first, that Protista are too heterogeneous, and do not admit of exact definition; but the third and most potent reason has, however, simply been that excessive specialisation which allows most otherwise competent students of the Protozoa to remain in entire indifference to the Protophytes, and the even more general and deplorable ignorance of the Protozoa which prevails among microscopic botanists.

The present theory, however, does away with the apparent heterogeneity of the Protista. On the view that Protozoa and Protophytes alike exhibit more or less specialised and abbreviated forms of a common life-cycle, the thirteen groups of Hæckel* are seen to be but forms of one, and there remains absolutely no morphological reason for their continued separation (nor for that matter, any physiological reason either, were such considerations, irrelevant as they are to morphological taxonomy, any longer admissible). Nor is the objection of Huxley really valid. The limit between *Protista* and *Animalia* remains simply that between Protozoa and Metazoa; and that between Protozoa and Protophytes being given up, there remains no more difficulty of separating the higher plants than there was before—a difficulty which, however undoubted, is not increased by uniting the lower forms.

The thorough unity and naturalness of the Protista being thus obvious, they naturally fall into a series corresponding to the stages of the life-cycle. In the Schizomycetes and the Palmellaceæ the resting and motile stages are almost equally prominent, while in Gregarines, and still more in Desmids and Diatoms, and especially Saccharomycetes, the encysted stage predominates. The Protoplasta, Foraminifera, Heliozoa, and Radiolaria represent of course the predominatingly rhizopod or amœboid stage, while the Infusoria represent the ciliated, and the Myxomycetes, as has been said, the plasmodial.

It may at first sight seem as if the old grouping of Protophytes and Protozoa were not seriously modified, since the Protophyta always essentially corresponded to the series of generally encysted forms. And so far true; the encysted series may still be termed Protophytes without any serious harm. But it must be clearly observed that there remains not *one* morphological type merely, to be discriminated as Protozoa, but *three*—the ciliated, amœboid, and plasmodial,—all, indeed, physiologically analogous in exhibiting movements (a phenomenon of which pure morphology takes absolutely no cognizance), but as distinct in form from each other as from the encysted form. The utter confusion which has too long maintained as to the distinction of plant and animal life is thus seen to be due to the want of that discrimination of morphological from physiological considerations, which is now happily nearly complete in the study of higher organisms. In short, though the encysted and usually non-motile cells or cell-aggregates may be conveniently termed plants by the physiologist, and though usually non-encysted and motile cells or cell-aggregates may similarly be grouped as animals,—yet the morphologist, distinguishing form-history from life-history, must recognise among the Protista four main lines of differentiation, or four series, which may perhaps conveniently be termed *Protophyta*, *Rhizopoda*, *Ciliales*, and *Plasmodiales*. (See Plate IV. figs. 1–13 in first series.)

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* *Die Protisten.*

5. *Phylogeny of Protista.*—On this view also there is no necessity for the assumption lately coming into view of the origin of the Protista from several distinct stocks, or for accepting, with Bergh,* so specialised a form as *Peridinium* as a type of the primeval Protozoon, for all are naturally derivable from a simple Myxomycete or Protomyxoid ancestor. Of course, this view by no means excludes the possibility of the remoter and simpler Protamœboid progenitor assumed by Hæckel.

6. *Relation of the Protophytes to the Higher Plants.*—Transverse division may of course occur in the encysted, amœboid, or ciliated stage of the life-cycle of a cell. When this takes place chiefly in the encysted state the tough and coherent wall holds the resultant cell-aggregate together; this cell-aggregate soon becomes moulded by the force of the environment into some definite form; and what we term a vegetable organism (a Metaphyte corresponding to a Metazoon) is the result.

But the cells of our multicellular plant do not lose their tendency to cycle. Alike in linear, superficial, or solid aggregates, the cycle is plainly seen: and it is scarcely necessary to remind the reader of the zoospores of a confervoid Alga, or of the similar mode of reproduction of an *Ulva*. It may be objected that here only two stages of the cycle are present; but a third, the amœboid, not uncommonly occurs, for that the brief quiescent state of the zoospore before re-encystment may fairly be considered amœboid, is demonstrated by such observations as those of Reinke,* who has lately figured a true amœboid stage in the settling zoospore of *Bangia*.

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* Bergh, "D. Org. d. Cilio-flagellata," *Morph. Jahrb.* vii. 2; Abstract by T. J. Parker, *N. Z. Jour. of Sci.*, October 1882.

In Fucus, again, the ovum-cell has rejuvenesced, in other words has gone through an amœboid stage, while other cells rejuvenesce as antherozoids into the ciliated phase. In the terrestrial Archegoniata, too, we have the same phenomena; even in the Phanerogams, condemned as all their cells seem to perpetual incarceration, there remains one fleeting and imperfect recapitulation of the cellular life-cycle in the embryonic rejuvenescence of the pollen grain and ovum cell (see fig. 15).

7. *Relation of Protozoa to Higher Animals.*—If transverse division occur in the ciliated state, the new cells must necessarily almost invariably separate, must row apart, and thus it is natural that only comparatively few and transitory cases of ciliated aggregates are known. In the amœboid state, however, the aggregate produced by division remains much more readily in continuity, and it would thus seem much more probable that the Metazoa should originate from Protista in which the amœboid stage was somewhat more permanent and more subject to division, than from the ciliated forms, as has sometimes been suggested, particularly for the sponges.

8. *Common or separate Descent and Affinities of Animalia and Vegetabilia.*—If the preceding facts and deductions be accepted, it need only be briefly pointed out, that the affinities of plants and animals are far closer than botanists and zoologists are generally accustomed to assume, since both are descended from a Protomyxoid ancestor, and may, in fact, from our present point of view, be described not merely, as the common phrase goes, as amœboid or encysted cell-aggregates, but as aggregates of Protomyxomycetes, variously grouped and arranged indeed, but never so highly specialised as to lose all traces of their individual ancestral life-cycle. The notion of *three* kingdoms of nature—animal, vegetable, and

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* *Op. cit.*

mineral—"that disastrous philosophic and scientific aberration" bequeathed by the alchemists to the last encyclopædist of Gesner's school, and unfortunately adopted and sanctioned by Linnæus, has not of course been seriously adopted by any philosophical biologist of the century; hardly the narrowest specialist among zoologists or botanists any longer seriously doubts the validity of the classification of natural objects into two groups only—inorganic and organic—yet, at the same time, the vicious results of the earlier dogma still everywhere survive, and indeed necessarily so. For the unity of plant and animal life requires morphological demonstration, and that more precise than has hitherto been afforded by merely separating off the lowest plants and animals into a third still heterogeneous group of *Protista.* This deficiency is supplied by the present argument, for if the Protista, the Vegetabilia and the Animalia have indeed been correctly interpreted, as somewhat variously specialised cell-aggregates derived from an ancestral Protomyxomycete, their consolidation into a single kingdom is a matter of course. In one edition of the *Systema Naturæ,* Linnæus clearly recognised the fundamental unity of plants and animals, by uniting them in opposition to the non-living world (*Conserta*) as *Organisata,* and this term it is accordingly not only convenient, but necessary forthwith to revive.

9. *Morphological Classification of Animal Tissues.*—Histologists are accustomed to recognise three main groups of animal tissues. Thus Cornil and Ranvier* distinguish (1) connective tissues, in which the cells are united and separated by a substance of characteristic form and properties; (2) muscular and nervous tissue, in which the cells have undergone extraordinary modifications, both structural and functional; (3) epithelial tissue, in which the cells possess a regular and constant evolution.

In this classification, however, as in so many others, morphological and physiological characters are not kept distinct. In briefly glancing at morphological characters only, it is evident we may best approach the problem by first noticing some of those cellular transformations made known by the recent students of embryology. Histogenesis must underlie histology.

An ovum is at first a naked amœboid cell, then assumes the encysted state, then segments into an aggregate of amœboid cells; this becomes perhaps a ciliated morula, this again a gastrula, with ciliated ectoderm and amœboid endoderm; this may settle down as in sponges, its cells re-cycling anew, the ectodermic layer becoming amœboid, the endodermic ciliated (fig. 18). The endodermic cells remain permanently more or less amœboid, as the recently much investigated phenomena of intercellular digestion have so clearly established. The amœboid ectodermic cells, on the other hand, may give rise to muscle—and a muscle is but an amœba elongated so as permanently to contract along one line; on the other hand, they may pass into a quiescent state, or throw out encysting material, which may either enclose them individually, as in Ascidians, or form a collective external envelope, as in Arthropods. The mesodermic cells may either remain unspecialised as amœboid corpuscles, may specialise as muscular tissue, or cycle into the resting state, *i.e.*, develop into connective tissue (see fig. 19).

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* *Manuel d'Histologie Pathologique,* i. p. 11, Paris, 1881.

And if the cell cycle persist thus long in the life-history of the organisms, why should it disappear? In reality, it does not disappear completely. The amœboid corpuscles of the perivisceral fluid of an invertebrate—say an Echinus—develop, largely at least, from the ciliated epithelium lining of the cœlome—permanently exhibit, that is to say, one of the most characteristic phenomena of the cycle. And when under proper precautions we examine a fresh drop of the fluid, we observe the corpuscles as they die running together into a plasmodium,* so perfectly similar to that of a Myxomycete as actually to have been described by a recent observer as a new genus and species.† And this phase of the cycle takes place, in the so-called coagulation of corpusculate fluids of invertebrates generally.‡ Numerous other instances of the occurrence of some phase of the cell-cycle have been recorded, and have already been collected by the writer in a series of papers which have led to the present one; it is unnecessary to call attention to others, save perhaps the especially interesting announcement by Professor Haddon,§ of the occurrence of a plasmodial union of cells during the normal histolysis of Polyzoa.

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* Geddes, "Observations s. l. fluide périvisceral des Oursins," *Arch. Zool. Exp.* VIII.

† *Comptes Rendus*, t. lxxxii. No. 21.

‡ Geddes, "On the Coag. of Amœb. Cells into Plasmodia," &c., *Proc. Roy. Soc. Lond.*, No. 202, 1880, and *Trans. Roy. Phys. Soc. Edin.*, 1882.

§ Haddon, "On Budding in Polyzoa," *Quart. Jour. Micros. Sci.*, 1883.

Thus then it will be sufficiently evident that the morphological classification of tissues must be based upon the cell-cycle, the various permanent tissues being viewed as specialisations of one or other of its fundamental forms, or perhaps sometimes as synthetic types between them. And, finally, compressing the gist of several possible papers into as many passing allusions, it is evident that the theory affords us a basis for the criticism and compression of the recent literature—(1) of intercellular digestion (natural to the amœboid phase); (2) of that long dispute respecting the origin of the sexual elements of *Hydrozoa*, from ectoderm to endoderm (the cells of both of which show the cycle, and either layer thus develop ova or spermatozoa); (3) of the cœlome theory.

10. *Physiological Rationale of the Cell-Cycle.*—It is now time to demand some physiological rationale for this cycle, which has been hitherto regarded as of morphological interest alone. A mass of protoplasm anywhere is under constantly varying conditions—at one time receiving abundant energy from the environment, at another little or none. These variations are at least of three main kinds—(1) temperature, (2) light, (3) food. Thus, then a rhythm of more or less vital activity in definite relation to these conditions of the environment is inevitable.

It is unnecessary to remind the histological reader how often and how easily the existence of this rhythm is verified by actual observation. Every student is shown the intensification of amœboid or ciliary movement by heat, and its depression by cold or electric shock, and knows too the influences of various reagents or gases (*i.e.*, of modification of *food* in the general sense) in stimulating or retarding activity. The dependence on climate of the cell-cycle of the lower organisms, *e.g.*, *Protococcus* or *Amœba*, is familiar to every microscopist. The amœboid state varies widely with food and temperature; while the actual transition from the ciliated stage to the amœboid, and conversely, have been repeatedly observed; witness the papers of Hæckel, Lankester, and others including the writer.* They can only be viewed in fact as distinct from the morphological point of view; physiologically, they show but the extremes of one motile state.

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* "On the Morphology and Physiol. of the Cell," *Trans. Roy. Phys. Soc. Edin.*, 1882.

Vast importance has been attached to the cellulose wall, as an assumed characteristic of plants, yet not only the cyst of a Myxomycete, but that of an Amœba, is now known to consist of cellulose. How is this cellulose wall to be accounted for? Why should the resting phase possess a cyst? What is the physiological rationale of this morphological characteristic of the resting phase?

Contracting muscle evolves carbonic acid and water, with evolution of heat; the quantity of heat and water products evolved diminishes as contractile activity diminishes; and this physiological common-place must hold true of every contracting cell, ciliated or amœboid. But contractility implies waste of formed materials, diminution of contractility therefore implies diminution of this disintegration of matter and dissipation of energy, of this combustion which we term waste. Cessation of contractility, therefore, involves cessation of the combustion of some product—of some fuel which was formerly required to maintain the process. *The cellulose wall which appears on the assumption of the quiescent state is thus the equivalent of the carbonic acid and water which were being formed and excreted during the state of contraction.* Being no longer required as fuel, it becomes itself thrown out as a waste product—which simply by reason of its chemical and physical properties—its insolubility and coherence—acquires at once its morphological permanence and its protective use.*

The applicability of this physiological conception to a new series of problems can here only be briefly hinted at. Without more than mentioning the discovery of Durin as to the formation of cellulose from cane sugar,† it may be briefly pointed out (1) that the occurrence of cellulose in Ascidians, or in pathological cases in the human brain, &c., is by no means unintelligible—the difficulty is rather the reverse—to explain why it is not invariably present in resting cells. These are never destitute of external intercellular substance, and the hypothesis thrown out many years ago by M. Frémy, our leading authority upon the chemistry of cellulose—that chitin and other analogous bodies really consist of cellulose linked with a proteid, seems well worth reviving. On this point the researches of Krukenberg,* especially are promising light.†

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* A vivid confirmation of the preceding theory of the origin of the cellulose wall has been suggested to me since the reading of this paper by my friend Dr Milne Murray, who reminds me that a quiescent muscle, instead of evolving carbonic acid and water, produces an enormous store of muscle-sugar or inosite, and that this is an isomer of cellulose, $C_6H_{10}O_5$. The same conception may throw light upon the physiological chemistry of other carbohydrates, such as glycogen, starch, &c.

† *Ann. Sci. Nat. Bot.*, 1877.

11. *Origin of the process of Sexual Reproduction.*—The plasmodial stage which terminates the cycle, seems in the first place little more than a mere mechanical union of cells exhausted by prolonged activity; in all normal cases it is soon followed by prolonged repose in the encysted state, and in the experiment upon invertebrate corpuscles, by quiescence and death. In the plasmodia of Protomyxa, Myxomycetes, and of invertebrate corpuscles alike, notably Echinus, the union is followed by a brief but extraordinary intensification of amœboid activity‡—the cause of which, as passing from cellular to protoplasmic physiology, must be discussed in a subsequent paper.

Some years ago considerable weight was attached by Sachs § to the hypothesis that the plasmodium formation of Myxomycetes might be regarded as a process of multiple conjugation. This view he now, however, withdraws,|| mainly on the ground that the nuclei have been shown not to coalesce as in true conjugation. It appears to me, however, that on the present theory the revival of that hypothesis, though in a somewhat different form, is inevitable.

No one doubts that the sexual elements of plants and animals are represented by the very slightly differentiated conjugating cells of *Spirogyra*, or the almost undifferentiated cells of *Mesocarpus*. With these the conjugation of two Amœbæ, two Actinosphæria or two Gregarines, are classified as a matter of course. But the recent observations of Gabriel upon the multiple conjugation of Actinosphæria, or of Gruber upon that of Gregarines, leave no doubt that in these cases at least conjugation may be multiple. The only difficulty is that offered by the non-coalescence of the nuclei. But even if there were any certain grounds for supposing that the essence of the process lies in the union of the nuclei, rather than in

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* Krukenberg, *Vergleich. Physiol. Studien*, Bd. ii.

† *Ann. Sci. Nat. Bot.*, 1877.

‡ See figure of plasmodium of Echinus in author's papers in *Arch. Zool. Exp.* VIII.; *Proc. Roy. Soc. Lond.*, 1880, or *Trans. Roy. Phys. Soc. Edin.*, 1882.

§ *Manual of Botany*, 1st Eng. ed.

|| *Ibid.*, 2nd ed., Appendix.

the union of the protoplasm, we must expect on the evolution theory an incipient stage in which only the latter phenomenon should occur. That the nucleus is not invariable, much less indispensable, is of course evidenced by the existence of the Monera, or if their distinctness be questioned, we may appeal to the recent demonstration, apparently by the most refined histological appliances, that in young *Actinophrys* a nucleus is really absent,* and develops independently in adult life. Moreover, on the present view of the almost primordial nature of the Myxomycetes, their plasmodium is the only phenomenon which at all resembles conjugation, and since we have already viewed amœboid, ciliated, and resting forms as specialisations of the corresponding phases, it is no great extension of the theory to view conjugation as specialised from the plasmodial phase. This view will be strengthened when in the next paper we leave the cell-cycle to consider the physiological processes in the protoplasm itself.

12. *Relation between Normal and Pathological Tissues.*—Unless the step taken by Goodsir and Virchow—of regarding all pathological variations as ultimately expressible in terms of cellular structure and function, *i.e.*, of the cell theory, be deliberately retraced, we cannot avoid the application of the present re-statement of the cell theory to pathology. To do this in detail would, of course, require far more than the writer's knowledge, but a few brief and tentative suggestions may be put forward. Pathologists are reducing tumours to a common type—which seems essentially that of cell multiplication in the resting or encysted stage. It is certainly more easy to suppose, on the present view, that the appearance of a connective tissue tumour has been due to the placing of ordinary cells in new conditions favourable to the assumption of that phase of the ancestral cycle; or from a slightly different point of view, to say that that inhibition of the cycle essential to the permanence of the whole organism has been locally removed, than, for instance, to suppose, with Cohnheim, the existence of a long dormant mass of embryonic tissue.

Again, we can easily modify the environment of living cells under the microscope—we can accelerate or diminish the activities of ciliated epithelium, by heat and cold, oxygen and carbonic acid, by alkali and chloroform. I have elsewhere † pointed out that the solution of the old dispute, as to whether the integument of certain planarians was amœboid or ciliated, was afforded by specimens of *Convoluta* which had been kept for many days in a shallow aquarium, scantily protected at nights from the cold of a severe winter. The normally ciliated cells of the ectoderm could be watched in actual progress of collapse into the amœboid state, and their cilia figured during their passage into pseudopodia (fig. 24). Here was a definite pathological change, in approximately known conditions, and distinctly in terms of the cell-cycle. Why should not a disorder of the ciliated epithelium of the bronchial passages be at least partly susceptible of essentially the same explanation? (fig. 25). May not the formation of pus be partly interpreted in terms of degeneration to the amœboid stage, and may not inflammatory changes be regarded as temporary and excessive intensifications of cellular activity, indicating a tendency to reversion to the amœboid state?

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* Gruber, *Zool. Anzeiger*, No. 118, 1882.

† *Op. cit.*, *Proc. Roy. Soc. Lond.*, 1879.

Whether these particular instances be acceptable to professed pathologists or not is after all a minor consideration, their aim has been merely to suggest that the phenomena of the cell-cycle—and particularly of those changes occurring under definite experimental conditions—may be applicable in their hands to fruitful research, not only in pathological histology, but in cellular physiology and therapeutics.*

Its adaptability to the treatment of physiological speculations is also obvious. Since the activities of the body are the aggregate activities of its component cells, not merely such phenomena as those of varying ciliary activity, but those of fatigue and sleep, of muscular and nervous tonus, and in fact every rhythm of increasing and decreasing cellular activity, become intelligible when viewed from this most highly generalised standpoint of physiology, as specialisations of that primeval cellular rhythm which lies before us in this life-history of the Protomyxomycete.

13. *Influence of the Environment upon the origin of Plants and Animals.*—One further physiological consideration may be briefly indicated, from its bearing on general morphology. The cell-cycle in its entirety is only possible in a fluid medium. Without water cilia cannot play, without fluid the amœba and the plasmodium must

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* This conception is somewhat developed in the subsequent paper.

alike become stationary, and either dry up or encyst themselves. The cell-cycle in plants therefore is only found in its entirety in algæ. Archegoniates are indeed terrestrial, but their brief cell-cycle during fertilisation is absolutely dependent upon the abundant moisture, without access to which neither moss, liverwort, nor prothallium ever occurs. Thus it is that the higher terrestrial plants have become restricted to the encysted phase. Only to escape death, has the dryad become thus shut up within the tree; but once so protected the extensive replacement of the cryptogams by the phanerogams, in all the less humid climates of the world, is readily accounted for.

Passing to animal life, the vast preponderance of aquatic forms over terrestrial, is very similarly to be accounted for by the aid of the present theory. Only the higher members of a few groups have successfully emerged from their native element, and their existence depends upon their differentiation of an internal fluid medium, of that "milieu intérieur" upon which Claude Bernard was wont to lay such stress,* this in turn depending upon the early differentiation of internal cavities. The interdependence of morphological and physiological theory will be sufficiently obvious from such considerations.†

14. *Theory of Variation.*—The more completely one accepts and reflects upon the theory of natural selection, the more one feels the necessity for some view more satisfactory than heretofore of the causes of variation.‡ The present conception of the cell-cycle seems to go far towards supplying this. On the ordinary conception of the cell theory, that of the plant as an aggregate of encysted cells, and of the animal as an aggregate of essentially amœboid ones, the organism cannot be credited with any innate variability—its observed variations are merely those which it receives, so to speak, between hammer and anvil—from the forces of the environment. The present conception, however, of all cells, however varied and specialised, being essentially differentiations from an encysted, an amœboid or a ciliated form, and of these forms as phases of a single form-history, enables us to credit the cells and the resultant organism with an innate tendency to variation, and this along

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* *Phénomènes de la vie communs aux an. et aux vég.*, Paris, 1879.

† "Morphology," *Ency. Brit.*, 'Rel. of Morphol. to Physiol.'

‡ *Cf. Origin of Species.*

certain definite and investigable lines. These modifications would still of course be largely determined by modification in the environment, yet the change of view is considerable. On the former view the organism is a plastic but essentially inert mass, yielding passively to the forces of the environment; on the latter, it is an active community, of which some or many members, under the influence of any favourable change of conditions, or the removal of any restraints, external or internal, immediately press into other positions and functions, which however apparently new, are either specialisations of the existing, or reversions to an earlier type.

Variation and disease are thus most closely akin; for since all variations are ultimately cellular, pathological changes are simply definable as those variations which happen not to be conducive to success in the struggle for existence. And thus we might proceed further and further with the discussion of ætiology.

The preceding theory then, although its range of application, unlimited in the scale of organic nature, may at first sight alarm the specialist, is actually founded on a simple but solid basis of observed facts; it has been seen fairly to meet and co-ordinate the very numerous and hitherto, for the most part quite unrelated problems which were enumerated at the outset, and even to be applicable to numerous minor and unexpected problems which these suggested. And thus, were it even viewed from the standpoint of mathematical probability alone, it has received the most overwhelming verification.

(*Explanation of the Plate at page* 292.)

II. AN HYPOTHESIS OF CELL STRUCTURE.

1. *Statement of the Problem.*—Great attention has, especially of recent years, been paid to the problem of cell structure, and a vast body of observations have been accumulated. Of these many are generalised; many, however, still remain unco-ordinated, and an hypothesis which attempts at once to unify these, to throw light upon the structural and functional aspects of contractile protoplasm, and to unite all these with that theory of the cell-cycle above propounded, is therefore not untimely, and may, even if not completely exhaustive or satisfactory, be at least suggestive of a better explanation. Let us survey a few of the main peculiarities of protoplasmic structure which any such hypothesis must aim at unifying.

The lowest amœboid organisms are simply granular masses of protoplasm, but higher forms exhibit a differentiation of a hyaline zone of "ectoplasm" around a more fluid and granular "endoplasm." The immense variability of form, size, and general appearance present among the rhizopods has never been sufficiently allowed for; so that there is ample reason for doubting whether great numbers of described species have any real distinctness. Yet the elongated and reticulated, granular and circulating pseudopodia of the Foraminifera, and the radiating, clear, and far less contractile pseudopodia of the Heliozoa and Radiolaria present a most vivid contrast, which we have as yet no means of explaining. The remarkable changes presented by ova both before and during fertilisation,* and the doubtless fundamentally similar phenomena exhibited during cell division, require to be accounted for; while the long dispute as to whether the "granules" of protoplasm are really granules at all, or are the optical expression of the intersections of a stroma or network of denser protoplasm, cannot be omitted. Such a hypothesis must also aim at throwing light upon the mystery of muscular structure, and must also deal even with such apparently peculiar and exceptional phenomena as that "aggregation of the protoplasm," first described by Mr Darwin as occurring in certain cells of insectivorous plants † (which, when in active digestion, or when subjected to chemical, electrical, or even mechanical stimuli, exhibit an aggregation, or rather segregation of the protoplasm into two portions—the outer more or less hyaline, but containing irregular and constantly-changing streaks and granules of a more refracting and fluid substance, in which the colouring matter, when present, became accumulated).

2. *Statement of the Hypothesis.*—Darwin soon extended these observations to the protoplasm of root hairs, and went on to indicate its wide prevalence throughout the vegetable kingdom. His researches were verified and extended by Francis Darwin,‡ who showed that these granules did not consist of sap, as some vegetable histologists had suggested, but were essentially protoplasmic in their nature. It is the object of the present paper to apply these facts to

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* Balfour, *Embryology*, vol. i.

† Darwin, *Insectivorous Plants*, London, 1875.

‡ *Quart. Jour. Micros. Science*, xvi.

the explanation of such problems of cell structure and contractility as those briefly enumerated above.

On this view, the granules of such a low vegetable organism as *Torula* (disregarding, of course, sap vacuoles and fat globules) are aggregation products, an assumption by no means excessive, especially when we bear in mind the activity of the chemical changes which are going on during its life and growth. But if this step be taken, we cannot resist regarding the Amœba in the same way; its granules too are aggregation products, and the clear ectoplasm, when present, may be viewed as protoplasm in which aggregation is not occurring. The variations of amœboid organisms in more or less granular character (a fact familiar to every observer) is thus brought into obvious relation with the state of nutrition, or with the quality and quantity of external stimuli; and its observed increase when stimulated, and its diminution during the resting state, are thus naturally accounted for. In the same way, in the granular pseudopodia of the Foraminifera, aggregation is in progress, in the hyaline processes of the Heliozoon not so. The granules of cells in higher animals may be, at least to a very large extent, similarly explained; while the disputes as to the presence or absence of a stroma become clearer when we bear in mind the fact that Darwin's aggregation-masses are at least as often greatly elongated or spherical, and that they may run in any direction, and unite or separate to any extent. The remarkable differentiations of protoplasm visible during cell-division, as exhibited by ova (of course excluding yolk granules, &c.), may not improbably admit of the same explanation.

3. *Contractile Structures—Muscle.*—The excessively difficult problem of muscular structure has not as yet received any widely-accepted solution, and even respecting matters of observation the widest discrepancies exist. In many invertebrates we cannot even be certain whether the muscles are striped or non-striped, so contradictory are the observations, while in a recent important paper by Professor Haycraft,* the homogeneity even of striated muscle is maintained. Brilliant light has, however, been lately thrown upon the arena of controversy by Professor Rutherford's recent elaborate demonstration † that the discrepancies in observation are largely

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* *Proc. Roy. Soc. Lond.*, 1881.

† *Proc. Roy. Soc. Edin.*, 1883.

if not indeed altogether, to be explained by the fact that the different observers have studied their specimens in different stages of contraction. When fully extended, and then alone, the full complexity of the structure of striped muscle can be realised; with slight contraction Flögel's granules disappear, then Dobie's globules; finally, in completed contraction, the heads of adjacent sarcous elements come together, and the fibril is momentarily homogeneous, the former complexity reappearing on extension. So far Professor Rutherford's explanation—how does this come into relation with the present hypothesis? The doubly refracting portions of the muscle-fibrils may, on this view, be regarded as aggregation granules; for these must inevitably exhibit considerable regularity of form and arrangement, when we bear in mind that, if we admit the existence of muscle-fibrils at all, we imply that these possess a limiting surface,—of course tubular in form and ultra-capillary in fineness,—and still more so, if we assume with many histologists the existence of fixed points afforded by Krause's membrane.* In short, it is attempted to compare the aggregation-granules of a sundew, not only with those of an amœba, but even with those most complex and most peculiar differentiations of protoplasm observable in muscular tissue.

4. *Confirmatory Evidence.*—The present hypothesis is thoroughly in accordance with recent researches as to the nature and composition of protoplasm. Thus Brass† distinguishes cells into two layers,—the outer sensory, the inner nutritive, and describes phenomena which seem at least closely akin to aggregation.

Our knowledge of the development of muscle also supports the hypothesis. Thus, for instance, Wagener‡ shows that muscular fibres at first differentiate from the protoplasm of multinucleate cells, as perfectly smooth fibrils ("vollig glatte Fāden"), with interfibrillar substance. Later there arises, as a secondary differentiation, the refracting and non-refracting elements ("Isotropen and Anisotropen"), which can extend and diminish, also fuse together and again separate. In young heart-muscles these come and go under the observer's eye.

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* *Cf.* Author's Prel. Note in *Zool. Anzeiger*, No. 146, 1883.

† Brass, *Zool. Anzeiger*, 120, 1882.

‡ G. Wagener, "Ueb. d. Entstehung. d. Querstreifen auf d. Muskeln," *Archiv f. Anat. u. Physiol.*, *Anat. Abtheil*, p. 543.

5. *Further Study of Aggregation—Cellular Therapeutics.*—High as is the importance of observations upon preserved tissues, the present hypothesis clearly points towards the importance of continuous observation of living cells when treated with various reagents—a line of research which Professor Frommann* is at present almost alone developing, and with such remarkable results. We must observe the effects, not of ammonic carbonate only, but of the whole pharmacopœia, and not upon the tentacles of Drosera merely, but upon vegetable and animal cells and tissues from the lowest to the highest; noting the changes which take place in all the structures and functions of the cell, and this, under all variations of temperature, light, electric state, and for various periods of time.

Of the practicability and interest of such an investigation only a single instance need be taken. When one treats an *Actinosphærium* with dilute ammonic carbonate, the most striking change results; its pseudopodia disappear, its complex protoplasmic structure vanishes; it loses its regular spherical shape, and collapses into an irregular granular amœboid mass with blunt pseudopodia—(the very likeness of the ancestral amœba),—and then soon breaks up.

And similarly there is little doubt that such a reagent would produce marked effect upon the epidermic cells of growing tadpoles,—a convenient means of research. Thus we set out from these researches of Mr Darwin upon a general investigation into what changes chemical substances produce upon cells,—an investigation which touches the general question of pharmacy and therapeutics in the most direct way, and which we may in fact speak of as cellular therapeutics. The interest of the admission of a drug does not end when it has been conveyed into the stomach, but really begins there. We must know what happens to the component cells of the organism,—we must, in short, observe the therapeutic effects of reagents upon the cells of vertebrates,—an investigation which points far. Such observations would not require constant but only frequent attention for long periods, and are thus perhaps especially suitable for the skilled pharmacist.†

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* Frommann, "Untersuch. ueb. Struktur, Lebenserscheinungen u. Reactionen thier. u. pflanz. Zellen," *Jena Zeitschr.*, xvii. and sep. pub., Jena, 1884.

† *Cf.* Author's paper in *Jour. Pharmaceutical Soc. Lond.*, No. 714, 1884.

6. *Further Chemical Considerations.*—It is an observed fact that when amœboid cells unite into a plasmodium, there takes place the most remarkable intensification of the activities of the mass. The compound amœba seem possessed of all and more than all the activities of its component amœba—pseudopodia of the most extraordinary length and size are thrown out, and motion is far more rapid; in short, it would seem that not only are the activities of the component amœba summed but multiplied. The coalescing amœbæ may be regarded as serving as food to one another—their waste products and their surplus water are squeezed out and got rid of, and thus we can readily understand the summation of their activities. But how is this apparent multiplication of activity to be explained?

We have seen how carbonate of ammonia, an oxidised body isomeric with urea, is exceedingly stimulating to protoplasm; and Mr Darwin's researches have also shown that other alkaloids and waste products are excessively stimulating, and set up the most extraordinary aggregation; and that a poison, for instance, may act by excessively exaggerating this normal process. Here then is a use, not merely for the protoplasm, but actually for the waste products—the waste product of one cell acting as a stimulant when it meets the protoplasm of another. And from this consideration again new series of speculative applications radiate off in all directions. One may suggest that the use of the alkaloids in the coffee or strychnine or Calabar bean is not merely to protect the young embryo from being eaten by animals, but as a stimulant to germination. Or we may introduce the same conception into our speculations as to the uses of manures, in which the most valued constituents are precisely those salts which, like carbonate of ammonia, produce great aggregation.

Again, passing from the plasmodial union of cells to the probably derived union of ovum and spermatozoon, we cannot avoid imagining the latter bringing not merely a trifling contribution of additional protoplasm, but a store of substances especially stimulating to the vast mass of the ovum. And the identification above suggested of aggregation with the protoplasmic changes visible in the ovum after fertilisation, is thus seen to be by no means so improbable as might at first appear.

7. *Need of an Explanation of the Phenomena of Aggregation.*—

How is it that if we treat living protoplasm with certain reagents it breaks up into two substances? How are we to explain this observed fact? Is there any case known to chemists or physicists where a chemical reagent separates a substance, at first apparently homogeneous, into two distinct substances which afterwards reunite; or where an electrical or mechanical stimulus temporarily separates a complex mixture into its components? I am not aware of any parallel case; but the absence of an explanation underlying the phenomenon of aggregation itself is after all entirely outside, and subsequent to both the main thesis and the speculative corollaries of the present paper.

III. AN HYPOTHESIS OF CONTRACTILITY.

If we imagine a single drop of more or less fluid substance suspended in a surrounding medium with which it does not mix, its surface-tensions tend to keep it in a spherical form. This can of course be observed in a drop of oil or water, most conveniently in the well-known experiment in which oil is suspended in a mixture of alcohol and water of the same specific gravity. If now we interfere and elongate this drop, its surface tensions at once enable it to resume the spherical form, even against the resistance of the surrounding medium. It is inevitable to transfer this simple physical conception to explain the function of muscle. If the elongated components of the muscular fibre be more or less fluid (as we almost certainly know them to be, whether aggregation granules or not), they must needs also possess surface tensions; they must, therefore, also tend to shorten and broaden, and draw themselves into a sphere. And if all these multitudinous elements of the muscle are shortening and broadening, we have of course an explanation of that general shortening and broadening which we term the contraction of a muscle.

Moreover, just as the "contracting" drop of oil overcomes a resistance, so the "contracting" muscle overcomes a resistance equal to the sum of the minute resistances which the millions or thousands of millions of simultaneously contracting elements can overcome. Finally, an expenditure of energy must needs take place, and of this the "negative variation" of contracting muscle (perhaps of the contracting oil-drop also?) may afford the indication.

Be the latter suggestion valid or not, it is important to observe (1) that we have here (and for the first time so far as the writer is aware) an hypothesis which explains (*a*) the shortening and broadening of a contracting muscle, (*b*) its overcoming a mass resistance, in other words, that we have an explanation of the mode in which almost molecular movements are converted into movements of masses, a solution long sought by physiologists; and (2), that this hypothesis depends simply upon the more or less fluid nature of the essential muscular components, and is entirely independent of the acceptance or rejection of the hypothesis of the preceding paper, which suggests the identification of these muscular components with aggregation granules.

EXPLANATION OF PLATE IV.

In columns allotted to the four stages of the cell-cycle (encysted, ciliated, amœboid, and plasmodial) are arranged the corresponding phases of the form-history of a few typical Protozoa and Protophytes, as also a series of diagrams illustrating the normal and pathological form-history of the cells of higher plants and animals. All are thus seen to be referable to the Protomyxan or Myxomycete type.

Among the Protozoa proper (figs. 3–8) the cell-cycle is almost complete; the encysted and amœboid stages are invariably represented. The plasmodial phase is of frequent occurrence: in Infusorians, Gregarines, and Heliozoa that of multiple conjugation representing it, and demonstrating its essential continuity with conjugation, *e.g.*, diatoms and algæ (figs. 10–13), and even with fertilisation in plants and animals (figs. 14 and 16).

Fig. 18 shows the cell-cycle in a developing gastrula, *e.g.*, sponge. In fig. 19 the various tissues are classified in relation to the cell-cycle; the connective tissues to the encysted, the muscular to the amœboid type, &c., even the plasmodial phase being represented during the histolysis of Polyzoa. Fig. 19 represents the development of an invertebrate amœboid corpuscle, and fig. 20 its formation of a plasmodium when drawn, while figs. 20–25 continue the application of the same theory to the explanation of pathological change.

Monday, 17*th December* 1883.

ROBERT GRAY, Esq., Vice-President, in the Chair.

The following Communications were read:—

1. On the Change in the Peltier Effect due to Variation of Temperature. By Albert Campbell. Communicated by Professor Tait.

The object of this short paper is to give the results of some further experiments made with a view to determine the variation in the Peltier Effect due to change of temperature. These experiments are the continuation of a set of similar experiments described in a paper read to the Society in summer 1882.

The arrangement used was almost exactly the same as that employed in the former experiments—the measurements being made by means of an iron-German-silver thermopile bent into the shape of an arch, with the ends about ¼ inch apart, and placed so as to almost touch the junctions of the metals whose Peltier Effect was to be measured.

The neutral-points of the various pairs of metals were also measured in the usual way by heating up a junction in oil, plotting the temperature-deflection curve, and from it deducing the neutral-point. According to theory, the ratio of the Peltier Effect at temperature t_1 to that at t_2, is determined *solely* by the values of t_1, t_2, and the neutral-point of the metals used; therefore it was not necessary to draw the thermo-electric lines of the metals.

As I have no satisfactory measurement of the neutral-point of Pb–Arg, in this case the calculated ratio in column V. is from Professor Tait's diagram.

In the subjoined table, column I. gives the name of the pair of metals; II. and III. the lower and upper temperatures at which the Peltier Effect was observed; IV. the ratio of the Peltier Effects at these two temperatures *from the direct measurement;* V. the ratio calculated from the observed neutral-point given in VI.

I.	II.	III.	IV.	V.	VI.
Fe–Zn . .	23°·8 C.	99° C.	1·43	1·404	198° C.
Fe–Zn . .	28°·25	94°	1·373	1·3397	198°
Fe–Zn . .	24°·5	94°	1·429	1·353	198°
Pb–Zn . .	17°	96°·8	·416	·4275	− 79°
Pb–Zn . .	18°·25	96°·5	·488	·434	− 79°
Zn–Arg . .	18°	98°·5	·730	·638	− 330°
Zn–Arg . .	18°·5	86°·5	·718	·678	− 330°
Pb–Arg . .	18°·6	95°·5	·682	(·636)	...

[*Note.*—Mr Campbell sent me portions of his iron and German-silver wires to test. The electromotive force of a circuit of these wires was found to be almost exactly proportional to the difference of temperatures of the junctions between 10° C. and 100° C.—P.G.T.]

2. On the Problem of the Lathe-Band, and on Problems therewith connected. By Edward Sang.

That of the lathe-band is one of those simple-looking problems in elementary mechanics which present serious difficulties to the investigator. The problem is this—"So to arrange the several diameters on the fly-wheel and pulley-cone of the turning-lathe, as that the same band may suit for all." The solution consists of two steps converse to each other, the one being "to compute the length of the band from given diameters," the other "to compute new diameters which may suit the length so found."

If A represent the lathe centre, B the centre of the fly-wheel, and if a circle be described round B, having its diameter KBH equal to the difference between the diameters of the wheel and pulley, the two tangents GA, Ag, together with the arc gHG, give the excess of the length of the band over the circumference of the pulley, while the same two tangents exceed the arc GKg by as much as the band is longer than the circumference of the wheel. Now, if we write i for the angle GAB, and regard AB as the unit of linear measure, we easily find

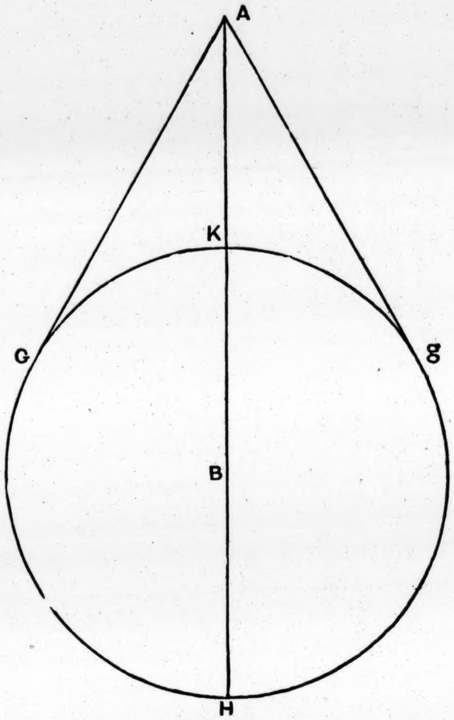


Fig. 1.

$$AG + GH = \cos i + (\tfrac{1}{2}\pi + i)\sin i = l,$$

$$AG - GK = \cos i - (\tfrac{1}{2}\pi - i)\sin i = l'.$$

Since i can be found from the difference of diameters, or that difference from i, the two branches of our problem come eventually to be "to find l and l' from i," and "to find i when l or l' is given." The first question is solved by help of the canon of sines; the second presents greater difficulty, we can get the value of i from that of l only by a series of trials. Yet, in truth, there is no essential difference between the two processes, both consist of trials; but the existence of the canon of sines, renders the trials in the former case so easy, that we come to regard the operation as direct. If we had a table of the values of l corresponding to all values of i from zero to the right angle, we would be able to resolve both problems with like facility.

In applying such a table to the business in hand, we should have to compute the circumference from the diameter, and afterwards the diameter from the circumference. This double arithmetical operation may be avoided by the simple contrivance of counting all in diameters; for the *length* of the band, we substitute the *diameter* of the circle which it would gird. Writing them

W = diameter of wheel,
P = diameter of pulley,
B = diameter for band, we have

$$W - P = 2 \sin i,$$

$$B - P = \frac{\cos i}{\frac{1}{2}\pi} + \left(1 + \frac{i}{\frac{1}{2}\pi}\right) \sin i,$$

$$B - W = \frac{\cos i}{\frac{1}{2}\pi} - \left(1 - \frac{i}{\frac{1}{2}\pi}\right) \sin i.$$

From a table constructed according to these formulæ, the dimensions of the lathe may be got by little more than inspection.

The actual table and the mode of using it, exhaust the mechanician's interest in the subject, but, to the speculative mathematician, some connected points may appear to be deserving of notice.

Our ordinary tables, arranged according to the ancient graduation, are exceedingly inconvenient, because the ratio $\frac{i}{\frac{1}{2}\pi}$ expressed in degrees and minutes would involve, in each case, a troublesome division. The decimal subdivision of the gradient was therefore preferred, and the computations made for each thousandth part, that is for intervals of 10′ centesimal. A manuscript canon of sines to 15 places (using however only 10 of these) rendered easy the computation of the terms

$$\left(1 + \frac{i}{\frac{1}{2}\pi}\right) \sin i \text{ and } \left(1 - \frac{i}{\frac{1}{2}\pi}\right) \sin i.$$

The canon of "sines measured in degrees" had been prepared, in order to compile the table of circular segments, used for the computation of the anomalies of the planets; the term $\frac{\cos i}{\frac{1}{2}\pi}$ was thus ready to hand. In this way the construction of the table for lathe-bands was greatly facilitated.

In all such calculations, the residual last-place errors may happen to balance each other, or may happen to concur in one direction, hence there is a possibility of error in the last place, proportional to the complexity of the work. This error may, in the present instance, amount to 2 or even 3 units in the last place. Hence it follows that, in shortening from *ten* places to the *six* places in the final table, an uncertainty in the sixth place must occur when the rejected figures are within the limits 4997 and 5003, as happens thrice in the course of the work. Hence the necessity for founding our working tables on more extensive ones.

All possible cases of the mechanical problem are comprised between the limits $i=0$ and $i=\frac{1}{2}\pi$; while i passes from the one to the other of these limits, the line AG makes the quarter of a turn, and we naturally inquire, What happens when the motion is farther continued? or how was it on the other side of the zero?

On changing the sign of i, the expressions for B − P and B − W change places; the wheel takes the place of the pulley. This is clearly seen in the second figure; the change from DC with its inclination inwards, to D′C′ inclined outwards, is accompanied by a reversion in the sizes of the circles. Hence it will suffice for us to examine the phases for values of i beyond the right angle.

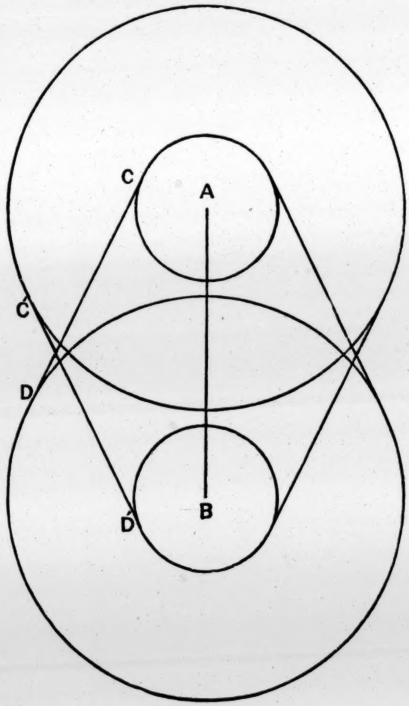


Fig. 2.

In order to this, let the circle described with the radius AE, fig. 3, represent the pulley, which we shall suppose to remain unchanged while the inclination of the band varies. When that inclination is zero, as in the position D_0C_0, the wheel is of the same size as the pulley; but when the band is inclined, as in the position DC, the radius of the wheel has grown to be BD or BM, and the half length of the band is made up of the three parts FD, DC, CE. When i becomes a right angle, the points

D and C have come up E, and the band encompasses the whole circle whose radius is BE.

Imagine now that the point of contact C has passed beyond E into the position c; the tangent takes the position dc, so that the course of the band is from F along the arc FDMd and back along dcE to E; the half-length being still made up of the three parts Fd, dc, cE; but in counting the length dc and cE must be regarded as subtractive.

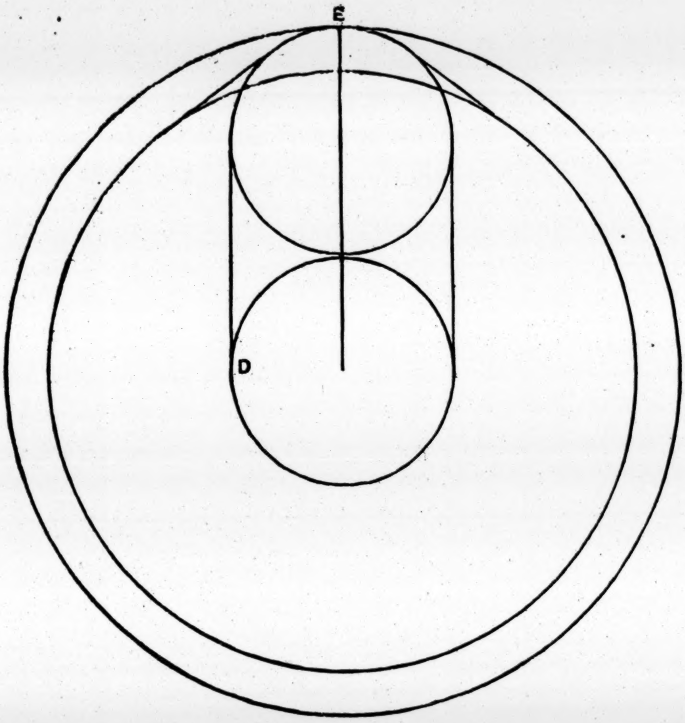
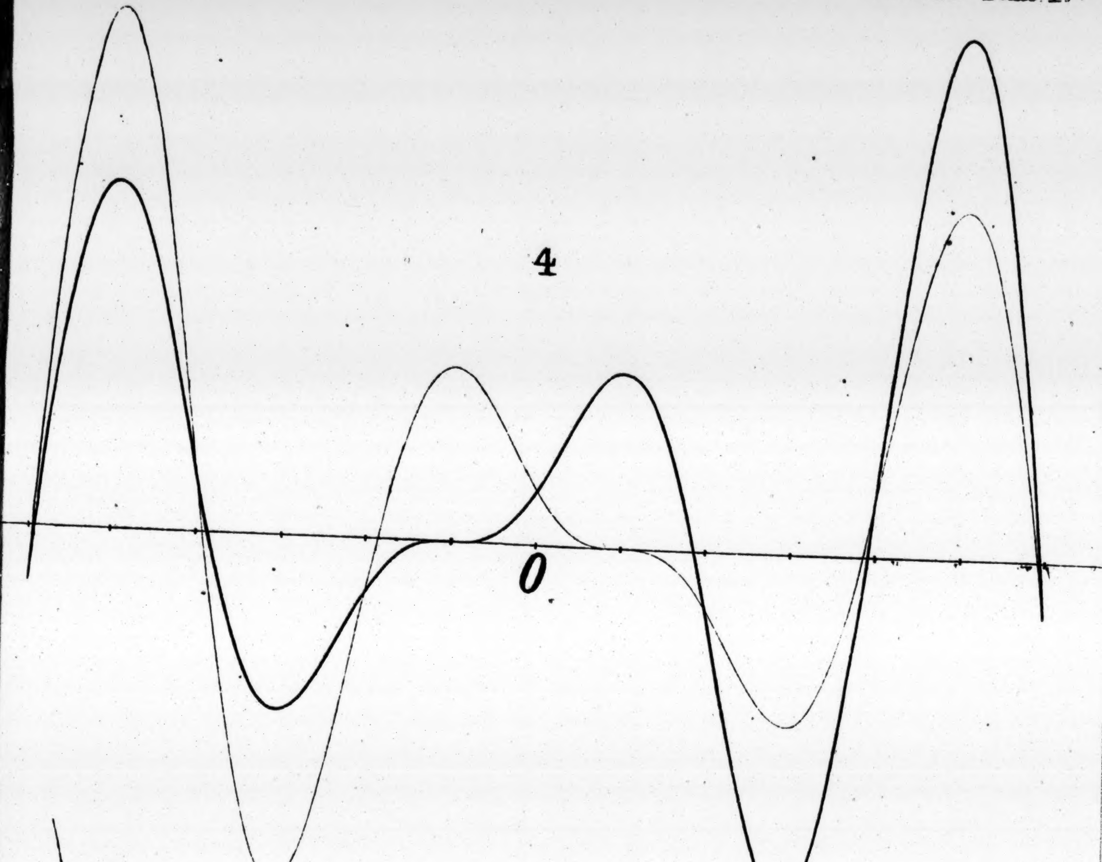


Fig. 3.

In this way the imaginary band is shorter than the circumference of the wheel, by as much as, in the symmetric position, the actual band had been longer.

Beyond the limits $i = \pm \frac{1}{2}\pi$, the mechanical arrangement fails to illustrate the properties of the above expressions, and therefore, regarding them as purely analytical formulæ, we may proceed to examine their characters.

Placing the arc i, representative of the inclination, along the line of abscissæ, and setting up the values of l and l' as ordinates, we



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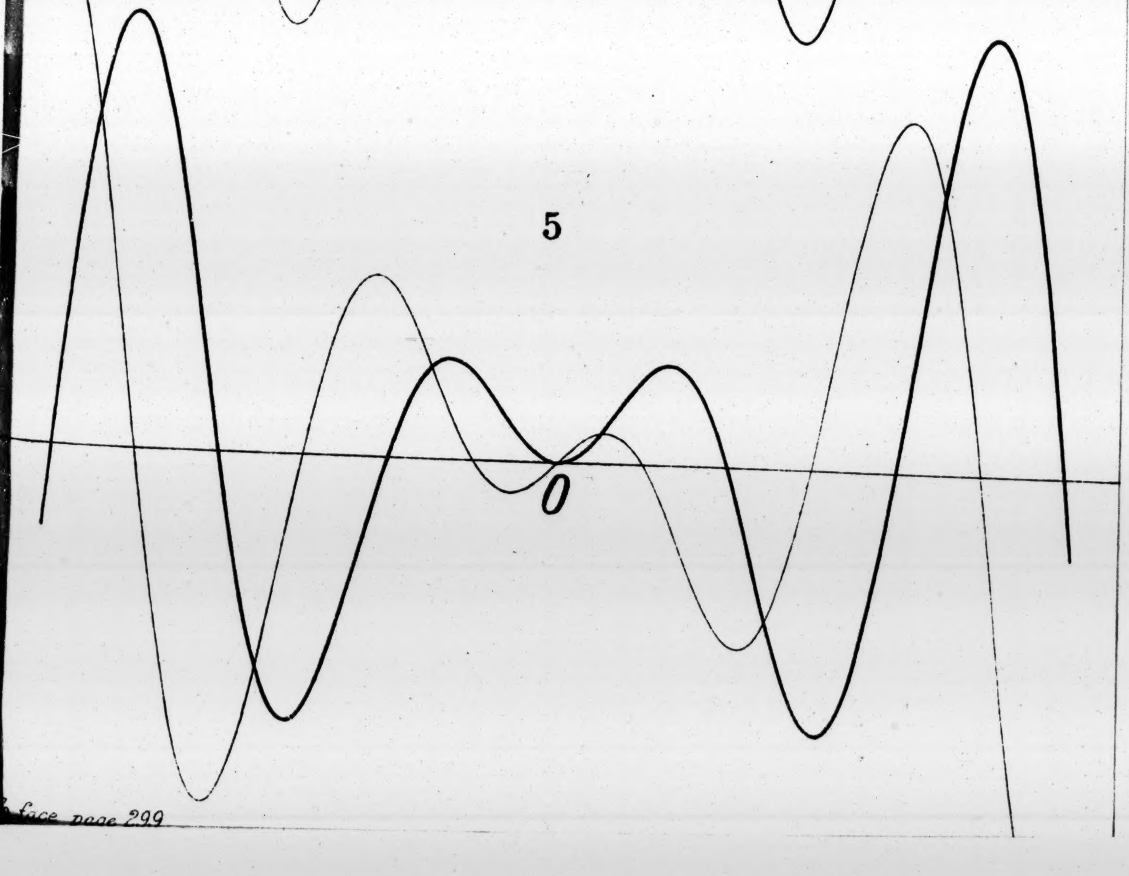

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obtain the curves shown in fig. 4; symmetrically placed in regard to the origin O; the one curve being converse to the other.

We may put these formulæ in a more convenient form by transposing the origin of abscissæ in the one case to $-\frac{1}{2}\pi$, in the other to $+\frac{1}{2}\pi$; for this purpose we write $x = \frac{1}{2}\pi + i$ or $-x = \frac{1}{2}\pi - i$, and in this way confine our attention to one of the curves, whose equation now becomes

$$l = x\cos x - \sin x\,.$$

In order to determine the singular points in the curve, we must take the first and second derivatives (differential coefficients) of this expression; these are

$$\frac{\delta l}{\delta x} \text{ or } {}_{1x}l = x\,.\sin x\,,$$

$$\frac{\delta^2 l}{\delta x^2} \text{ or } {}_{2x}l = +x\,.\cos x + \sin x\,;$$

and continuing the derivation,

$$\frac{\delta^3 l}{\delta x^3} \text{ or } {}_{3x}l = -x\,.\sin x + 2\cos x\,,$$

$$\frac{\delta^4 l}{\delta x^4} \text{ or } {}_{4x}l = -x\cos x - 3\sin x\,,$$

etc. etc.

The remarkable simplicity of this progression suggests the continuation in the opposite direction; taking the successive primitives (integrals), we get

$$\int\delta x.\ l \text{ or } {}_{-1x}l = -x\,.\sin x - 2\cos x\,,$$

$$\iint\delta x^2.l \text{ or } {}_{-2x}l = +x\,.\cos x - 3\sin x\,,$$

$$\iiint\delta x^3.l \text{ or } {}_{-3x}l = +x\,.\sin x + 4\cos x\,,$$

and so on;

and it is obvious that, in this endless progression of derived functions, the appropriate middle term is $x.\sin x$, which also has its conjugate $x.\cos x$. Denoting the one of these functions by Fx, the other by ϕx, we have the conjugate progressions :—

etc.	etc.
${}_{-4}\mathrm{F}x = +x.\sin x + 4\cos x$	${}_{-4}\phi x = +x.\cos x - 4\sin x$
${}_{-3}\mathrm{F}x = +x.\cos x - 3\sin x$	${}_{-3}\phi x = -x.\sin x - 3\cos x$
${}_{-2}\mathrm{F}x = -x.\sin x - 2\cos x$	${}_{-2}\phi x = -x.\cos x + 2\sin x$
${}_{-1}\mathrm{F}x = -x.\cos x + \sin x$	${}_{-1}\phi x = +x.\sin x + \cos x$
$\mathrm{F}x = +x.\sin x$	$\phi x = +x.\cos x$
${}_{1}\mathrm{F}x = +x.\cos x + \sin x$	${}_{1}\phi x = -x.\sin x + \cos x$
${}_{2}\mathrm{F}x = -x.\sin x + 2\cos x$	${}_{2}\phi x = -x.\cos x - 2\sin x$
${}_{3}\mathrm{F}x = -x.\cos x - 3\sin x$	${}_{3}\phi x = +x.\sin x - 3\cos x$
$\mathrm{F}x = +x.\sin x - 4\cos x$	${}_{4}\phi x = +x.\cos x + 4\sin x$
etc.	etc.

each term being the derivative of that above it.

On equating any one of these functions to zero, we get (1st) the intersection of its curve with the line of abscissæ, (2nd) the culminations of the curve belonging to the function immediately above, and (3rd) the points of reflexure of the curve of two steps up; hence we are mostly concerned with the solution of the general equation

$${}_{n}\mathrm{F}x \text{ or } {}_{n}\phi x = 0\,.$$

The equation $\mathrm{F}x = x.\sin x = 0$ is satisfied in two ways, by making $x = 0$ or by making $\sin x = 0$. Now $\sin x$ becomes zero for every value of $x = n\pi$, n being any integer positive or negative number, and hence the curve, shown in fig. 5, crosses the line of abscissæ at equal intervals of π, counting from the zero point; and since $x = 0$ coincides with one of the values $\sin x = 0$, the curve touches the axis at the origin.

The conjugate equation $\phi x = x.\cos x$, is also satisfied by putting $x = 0$ or by $\cos x = 0$, the latter condition giving for x any value of the form $(n + \frac{1}{2})\pi$; hence, besides the crossing at the origin, this curve crosses the axis of abscissæ at points distant by the interval π, reckoned from $\frac{1}{2}\pi$ on either side of the zero.

The solution of the adfected equations is somewhat more complex. Beginning with the case ${}_{-1}\mathrm{F}x = -x\cos x + \sin x$, which is that of the actual lathe-band, we observe that the function becomes zero when the condition

$$x = \tan x$$

is satisfied. We have thus the problem "to find an arc equal to its own tangent."

Having applied, at the end of the radius OA, a tangent to the circle, let us suppose two points thence to set out with equal velocities, the one q to travel along the tangent, the other p to move along the circumference of the circle, carrying with it an indefinitely extended radius Op. At first this secant will precede the point q, and by the time q has reached the distance Ab, equal to the quadrant AB, the intersection has moved off to an infinite distance along to tangent. After this the point of intersection reappears on the other side and comes up to A just when q reaches the distance Ac equal to the half-circumference ABC. The intersection now chases the travelling point q and comes up to it at Q, somewhat before p has reached the third quadrant. The first root of our equation, that is AQ or ABCP, is below the value $x = \frac{3}{2}\pi$. In the same way we readily perceive that the next root is when p has made more than an entire revolution by nearly a quadrant, that is when it has come to P′ a little before B; the root, then, is rather less than $\frac{5}{2}\pi$.

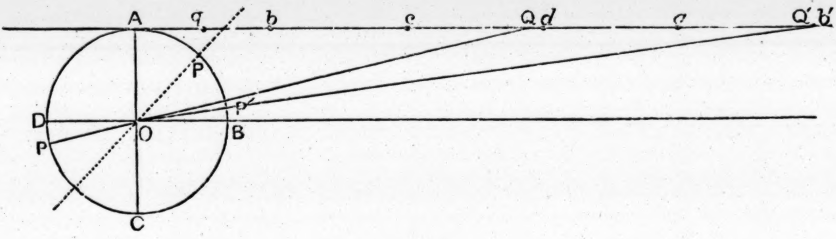

Fig. 6.

The numerical values may be found by a very rapid approximation. Assuming $x = \frac{3}{2}\pi = \mathrm{A}a$, we compute the arc of which this is the tangent; we regard the length of this arc as a new tangent, compute the length of the arc thereto belonging, and so continue until there be no change within the limits of the precision at which we aim. Three or four operations exhaust the precision of seven-place tables. The successive approximations are thus represented by the symbols

$$\tan^{-1}(\tfrac{3}{2}\pi),$$
$$\tan^{-2}(\tfrac{3}{2}\pi),$$

and so on, so that we have $x = \tan^{-\infty}(\frac{3}{2}\pi)$; where ∞ stands for an indefinitely large integer number.

The roots of this equation are actually

$$\begin{array}{rcrcr} & & c & & r \\ 257^{\circ}\!\cdot\!27 &=& 286\cdot06 &=& 4\cdot4934 \\ 442\cdot37 &=& 491\cdot80 &=& 7\cdot7252 \\ 624\cdot46 &=& 694\cdot17 &=& 10\cdot9041 \\ 805\cdot56 &=& 895\cdot48 &=& 14\cdot0662 \end{array}$$

For the crossings of the curve belonging to the function ${}_1Fx$, we get the condition

$$x = -\tan x,$$

and, in this case, the points p and q must move away from A in opposite directions, and the first coincidence will take place when p is somewhat beyond the extremity of the quadrant AB; the phases are so closely analogous to those of the preceding case that it is unnecessary to detail them.

The functions ${}_1\phi x$ and ${}_{-1}\phi x$ give the conditions

$$x = \cot x \text{ and } x = -\cot x.$$

In these cases, when q begins its motion from A along the tangent, the travelling point p must leave B, in the one case travelling backwards towards A, in the other case forwards towards C. Thus the same artifice serves for the detection of the roots in all the four equations.

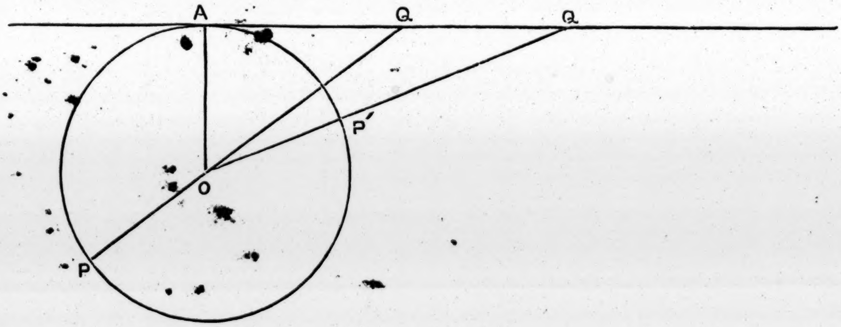

Fig. 7.

As an example of the other cases, we may take the function ${}_{-3}Fx = x\cos x - 3\sin x$; this, when equated to zero, becomes

$$x = 3\tan x.$$

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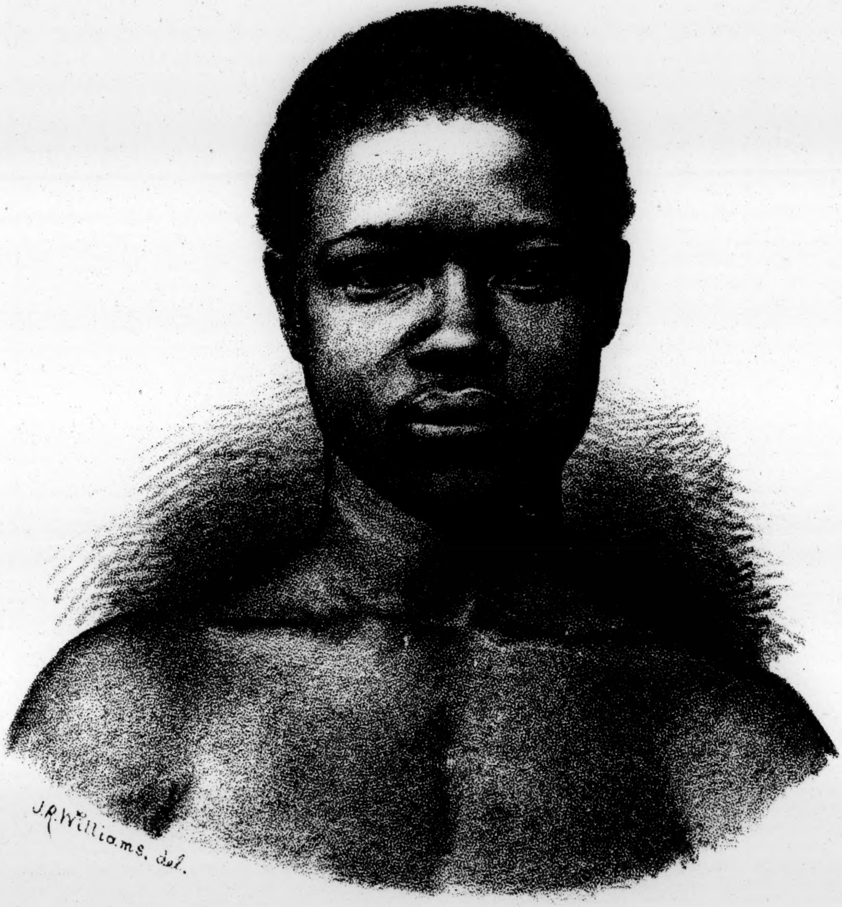
J.R. Williams, del.

A MADI OR MORN BOY, AGE ABOUT 17.

We shall therefore suppose that the travelling points p and q leave A simultaneously in the same direction, but that p moves thrice as fast as q; here we see that the radius Op must make more than half a turn before its intersection with the tangent can overtake q. Proceeding by the same method of approximation, we readily find the arc AP to be 233° 40′, its tangent AQ being 1.3594 in terms of the radius. Each succeeding coincidence must occur after an interval of rather more than half a turn, so that the approximations are rapid. The second coincidence is when $x = \mathrm{AP'PAP'}$ reaches 428° 07′, the tangent AQ′ being 2.4907.

The same method is applicable to the other cases of the general problem.

Thus the consideration of this elementary problem in mechanical construction leads us to examine the properties of a whole class of functions, which, again, may serve to suggest further extensions and inquiries.

3. Notes on the Madi or Moru Tribe of Central Africa. By Robert W. Felkin, F.R.S.E., F.R.G.S., Fellow of the Anthropological Societies of London and Berlin, &c. (Plate V.)

The following notes have been compiled from my own observation, when in Central Africa in 1880, from inquiries I made on the spot, and from the information I have obtained from a native who has been my faithful servant during the past few years.

They treat of a people inhabiting a large tract of country situated 5° N. lat., 30° 20′ E. long. of Greenwich, of which the chief town is said to be Bengué.

The Arab customs, which are being introduced among the races in Central Africa, are rapidly breaking down the boundaries which exist between the tribes, and superseding their primitive habits and customs, which in a few years will be things of the past. For this reason I have been induced to bring together all the information it has been my good fortune to collect, and whilst regretting that the record is not so complete as one could have wished, I yet hope that it may prove of some value, or at all events of interest, to those engaged in the study of anthropology.

The tribe called Madi by the Arabs give themselves the name of Moru, and must not be confounded with the Madis on the east of the Nile, or with another so-called Madi tribe on the west.

I am not able to give the exact population of the district, but I have ascertained that it has diminished considerably during the last ten years, owing to the fact that many of the people have been taken away as slaves, while numbers of the young men have been drafted into the Egyptian army, where they have obtained a reputation for courage, fidelity, and veracity.

I will commence by giving a description of the way in which the Madi builds his hut, so that you may first see him in his home, and then follow him as he goes to his daily work, or enters into the various pursuits of a far from monotonous life.

Habitations.—The process of constructing a hut is as follows :—A circle is marked on the ground by means of a string attached to a stick in the centre, and in this circle poles are fixed into the earth. These poles are made from thick straight peeled branches of a tree called "pi," and they are encircled by rows of supple saplings, which are tied to them at intervals of about 1½ feet. Grass is then taken, cut the same length as the poles, about 6 feet, and placed upright in bundles round the framework, after which saplings are again tied round to keep the grass in position. The roof is made on the same plan, a strong circular foundation of wood being first put together, into which wooden rafters are fixed, and being brought together in the centre, are secured at their upper ends. Circles of saplings are fixed on to the rafters, and then grass is laid on, and fastened as in the case of the wall. The top of the roof is formed of a large bundle of grass cut even and bound firmly together at the lower end. A stake about 4 feet high is thrust through it, and then fastened on to the top of the roof. The loose ends of grass are then bent downwards, and secured to the roof, and the free end of the stake is ornamented by an ostrich egg and feather.

There are no windows in these huts, and only one entrance, about 3½ feet high and 2½ feet wide; a door of wicker work is made to slide backwards and forwards inside across this entrance, and is kept in place by two poles fixed firmly in the ground, and tied at the top to the roof.

Trenches are dug round the huts before the rains set in at a sufficient distance for the water dripping off the roof to fall into them. A small channel from the trench carries off this water to a convenient distance.

Furniture.—These dwellings do not contain many articles of furniture. The principal one is the bed, which is made from the stem of a plant called yougo, resembling the sugar cane. Narrow pieces of the stem are cut about 6 feet long, laid side by side, fastened together by strips of cow hide, and then fixed on to three wooden cross bars. This is raised from the ground about 3 feet upon six thick round wooden legs, to which the cross bars are tied, the whole is then covered with a cow hide.

A large earthenware jar is an indispensable piece of furniture. It is about 4 feet deep and 5 feet wide, with a narrow neck, and is placed on a wooden stand, generally formed of the forked branch of a tree. It contains a good supply of semsem seed (Egnoir), which is used for making porridge, and from which oil is obtained. Another jar of the same shape, but smaller, contains water, and is placed near the entrance.

The bare ground, which is well trodden and beaten to make it firm, forms the floor, and a wood fire is generally burning in the centre of it. Jars of varying shapes and sizes are placed round the hut on the floor, or hung from the walls in string nets. They contain different kinds of dhurra, also honey, butter, dried sugar cane, salt, &c. Baskets made of dhurra stalks are also hung round the hut, more for ornament than use it would seem. Bundles of arrows, spears, bows, and knives serve the same purpose when not in use.

Besides the principal hut, each family usually has a hut for strangers; and as soon as children arrive at the age of four or five years, the father builds a separate hut for the girls and one for the boys, or several neighbours club together in these huts. These additional buildings contain only beds, a water jar, and a few basket work ornaments.

Granaries.—Another erection is constructed as a storehouse for dhurra. The circular wall is made like that of the other huts, of poles and grass, but it has a flat wooden roof upon which is fixed an upper chamber of basket work (literally a huge basket), in which the dhurra is kept. Over it is placed a roof similar to the one described above. This roof is kept in place by three poles which pass through its outer rim, and are fixed into the ground below, apart from the walls.

The lower part of this building is used as a kitchen, and contains a number of large stones for crushing corn, and jars for holding it. Meat is also hung from the ceiling. The dhurra can only be taken out of the granary from above. The roof is pushed up with a long pole, which when rested on the ground keeps it raised; a woman then ascends from outside by means of one of the three supporting poles, which is a kind of ladder, for it is made of a tree stem, the broken stumps of branches forming the steps.

Gardens.—Flowers are cultivated close round the dwelling huts, but the garden, which seems to be an indispensable belonging, lies behind the hut, covers generally a large extent of ground, and is devoted to the cultivation of fruits and vegetables. The beds are circular and raised about 3 feet, falling abruptly to the ground all round. Melons, gourds, and vegetable marrows are grown on them, and creep gracefully down the sides and along the unoccupied ground beneath. Some beds are 3 feet wide, and of great length, and are planted with sogo (yams?), which twine up a double row of sticks about 12 feet in height.

A poisonous bulb, in appearance like our onion, is planted round the dwelling, and its leaves are put about the huts to keep away serpents and mosquitoes. Arrows are also poisoned with it.

Cattle.—Cattle forms the chief wealth of the tribe. A rich man may have as many as 200 head, a very poor one only three or four. The average number possessed by one man is from thirty to forty. A large enclosure (or kraal) is erected for them at a short distance from the village, and cows belonging to different families herd together in one kraal. This is circular, with strong wooden walls and no roof. Inside there are two smaller enclosures—one for the calves, and one for the man in charge, the latter having a roof of wood and grass. A fire is made between these two divisions. Should the rains be very heavy, a temporary roof is constructed for the calves; sometimes even, the people take them into their own huts. The care of the cattle is not the work of one man in particular, but the owners take it in turns to sleep with them at night, and take them to grass by day. Cattle are never let out to graze till the dew is off the grass; eating wet grass is said to cause a plague. They are milked by men, and women make butter from the milk in gourds. The cows are called by names, either according to their marking, or, if favourite ones, after some near relation of the owner. They are not branded or marked in any way, but identified without. If a cow is troublesome, a bell is put round its neck.

In the holiday season the cows are taken by young men and boys to a distance, for change of air and food, and brought back after a few weeks. The people in whose district the cattle feed are permitted to use the milk, and in return provide the keepers with food and shelter.

There is a special kind of black cow (sometimes red), whose milk is kept solely for its master's use, or for its calf. A man usually possesses at least one such animal.

It is usual to kill cattle at the beginning of the rains, when they are needed for food by the people employed in sowing the crops.

Cows suffer from sore legs and serpent bites. In the first case, they are killed and eaten, but the flesh of those bitten by snakes is considered to be injurious.

Food.—The Madis consume a large amount of animal food, of which there is a great variety, especially in the hunting season.

The buffalo, tetel, wild boar, gazelle, and hippopotamus are all commonly eaten; while the elephant, rhinoceros, crocodile, eland, and fox are partaken of occasionally. Among domestic animals consumed are the cow, sheep, and goat, though cows are only eaten at harvest time and at funeral ceremonies. Wild ducks, pigeons, fowls, and guineafowls may be added to the list, and sometimes ostriches; but fowls are only eaten by young children and old people. Several varieties of fish are found in the rivers, and eaten.

Of the vegetables cultivated, marrows, cucumbers, sweet potatoes, yams, peas, beans, and greens are the principal; and the most common fruits are figs, nuts, melons, and the fruit of the date palm. Several varieties of dhurra are made into bread, as also occasionally a root called morako, but the bread is usually of the consistency of our porridge. A substitute for our butter is found in the semsem seed, which is roasted, ground, and eaten with bread. When people cannot afford this, they have recourse to "bottled white ants." Butter is made, however, and when used, is melted and poured over the porridge. Both cows' and goats' milk is largely used. Marrow, which is extracted from bones with a stick, is much relished.

There do not appear to be any articles of food forbidden, but some people do not think it well to eat liver, fish, sheep's head, or goats. The earth thrown up by ants is sometimes eaten, but those who do it are considered mad.

Oil is made from semsem seed. The seed is ground, boiling water poured over it, and the oil squeezed out with the hand on a grinding stone, caught in a gourd, and poured into jars.

No spices are used, but redeb, a stone fruit, is made into a pulp, and mixed with porridge, when the latter is boiled. Salt is used, and is kept by some people for sale. Honey and deli stem are added to sweeten food.

The most expensive articles of food appear to be semsem, milk, cows, sheep, and goats.

Cooking.—The cooking is either done in the room under the granary, or outside the entrance to the dwelling hut, where three stones are always placed. Between these a fire is made, and the cooking vessels are placed upon the stones. The women are the sole cooks. They have a superstitious practice of putting white ashes on the pots before placing anything inside; some words are muttered at the same time, and this is supposed to make the food more satisfying when cooked. Small cooking operations are at times done in the hut.

Refuse is deposited in heaps about 100 yards from the hut, and cleared away periodically.

Meat will keep two days, but is considered at its best on the first day after killing. It is boiled and also roasted over the fire. Meat and fish are dried in the sun for keeping. Fresh fish is boiled; dried fish boiled or broiled. Fowls and all kinds of birds are boiled. No spit is used to roast meat; it is laid across two pieces of wood arranged over the fire. Meat is not fried. The use of hot stones in boiling is unknown. Porridge and bread are mixed in a pot over the fire, and bread is really only a very stiff porridge. Porridge mixed with redeb and semsem is made with water; that made of dokn flour, with a little butter added, is boiled with milk. Vegetables are eaten alone, bread being used with meat.

The cooking vessels are earthenware jars. Mixing sticks are the only cooking utensils used besides knives. They are cleaned after use. No vegetable broths or stews are made. Farinaceous puddings are unknown. Meat very well cooked is preferred. Preserving of fruit with sugar and pickling of vegetables are unknown.

The only beverages are water, milk, and dhurra beer. This beer is made by the women in large quantities, and kept in jars in a hut set apart for the purpose. To this hut the people go to drink. It is common property, and not paid for. They do not take the beer home, or drink it at meals.

There are three meals in the day—before sunrise, at midday, and at sunset. No ceremonies are observed at the commencement of meals, nor are there any religious rites connected with them.

When fine, meals are taken outside the entrance to the hut near the cooking place. It is customary for members of different households to meet together for dinner, each family providing a bowl of food, round which they sit, and eat from one bowl after another, using their fingers as spoons and forks. They always wash their hands before and after meals, a jar of water being provided for the purpose, but the water is not poured over the hands. The men and boys sit in one group, the women and girls in another. The women do not wait on their husbands, the food when ready being fetched by the children. Any stranger who may chance to pass by is invited to share the meal. Water is always kept at the door of the hut to give to passers by. Wooden stools are used outside the dwelling, but it is not considered proper to use them at meals. The gathering does not disperse directly the meal is over, but digestion is aided by telling and hearing tales.

No cannibalism exists in the country, and the people express great abhorrence of the custom as practised by their neighbours the Nyam-Nyams.

Fire.—Wood is used for fire, and lighted with dried grass. The fire is produced by friction of wood, one piece of wood about the size and shape of a large pencil being rapidly rotated in a hole in a flat piece of hard wood. One man holds the hard wood steady, whilst two others take it in turn to rotate the stick

Smoking.—Tobacco is used to a great extent for smoking, but it is not chewed, nor used as snuff. The native name is tabba, which is, however, commonly used in other tribes also. I believe the tobacco smoked to be indigenous, for none is imported. It is very good, but exceedingly strong. It is cultivated, and the leaves, being sun-dried and broken up in small pieces, are then mixed with a small proportion of dried cows' dung and urine, and moulded into conical cakes, weighing about $\frac{1}{4}$ lb. to 1 lb. each. These cakes are dried in the sun, and stored away in baskets hung up in the huts.

Two kinds of pipes are used, both made of clay. One measures about six inches long, with a very thick stem and oval bowl; the stem is not put into the mouth, but the lips are pressed round the hole in it. The other pipe is itself small, but has a wooden stem about three feet long; this pipe is rarely carried about, but smoked in or near the huts. The pipe is ignited by burning charcoal being placed on the top of the tobacco; a flaming stick is never used. Two small sticks serve as tongs to take the bit of charcoal from the fire.

Water pipes are unknown, and I have not heard of any substitute for tobacco; as that plant grows in great profusion, I should not imagine that one would be required. The people smoke a great deal, but do not carry the practice to any injurious degree. Other narcotics are to the best of my belief unknown. A root, however, is sometimes chewed, which has the repute of exciting sexual passion.

Agriculture.—A large area of land is cultivated. After the forest has been cleared away by felling and burning, the ground is hoed. Hoeing and weeding are the only processes which it undergoes. There is no irrigation, but the soil is prepared for the seed as soon as the first rain falls, after which there is plenty of water. The land is usually marked out in long narrow strips by large stones placed at equal distances. Each man cultivates his own land; and if it is of considerable extent, and requires more hands than his family can give, he calls in the aid of his friends and neighbours. On such occasions no pay is given or expected, but all are ready to give and receive help in this way.

The hoeing is done by men, and the hoes used are made of iron with wooden handles. The process of weeding is delegated to the women, and there are three kinds of hoes used for the purpose. Sometimes they kneel down between the rows of corn, and use a short one; or if standing, there are two other shapes employed. The two first kinds of hoe are made of wood and iron, the last solely of wood.

The married women always carry a knife in their girdles, which they use amongst other things for cutting corn. Its wooden handle is either carved or ornamented with iron. These implements are all of home manufacture, there being a good supply of iron in the country. The wooden handles are often ornamented, and differ much in shape. One very common shape I noticed was much that of a tortoise, but apparently there was no design in it; and no attempt seems made by these people to represent anything by carving, as obtains in other tribes.

Hammers and anvils are often made of iron, but stone ones are also used; there are no other stone implements.

The weeds are gathered together into little heaps, and left on the ground until it is prepared for seed again, when they are hoed in with the soil. Underwood is burnt on the field. Digging and mowing are dispensed with.

No animals are used in the cultivation of the soil.

Six months of the year are dry, and six months more or less rainy. At times the rains are very heavy. The corn is sown at the commencement of the rains, and some early kinds are reaped in fine periods between the rains. Most of the crops ripen and are reaped when the dry weather sets in. The soil is so fertile that two and three crops may be sown in one year.

There are four varieties of dhurra, besides dokn and telaboon, which are species of dhurra having very small grain. The seed of some of these kinds is mixed and sown together. An early and a late kind are sown in different rows in the same field. After the early sort (léli) has ripened and has been reaped, semsem is sown in its place, or sometimes the ground is planted with a kind of cucumber. A cereal called deli is sown in the gardens; its grain, however, is not eaten, but only kept for seed. The stems, which grow as high as 20 feet and about 2 inches in diameter, are sweet, and resemble sugar-cane. They are dried, peeled, and eaten uncooked; sometimes they are cut in small pieces, dried over the fire, ground, and mixed with semsem. Dokn stalks are dried in the huts, tied into bundles, and used as torches. The dhurra stalks are used as food for the cattle, or made into baskets. Salt is also obtained from them. The women burn them to ashes, which are mixed with water and well boiled, the water is then skimmed, stirred, and boiled down, and the salt dried. Salt is also made from the root of a tree, from the stalk of a cereal (yobung) grown for the purpose, and some is also obtained from salt springs.

When the corn is ripe, the women cut it, and tie it into sheaves, laying the stalks in opposite directions. The men collect these bundles, and carry them on their heads to the "langas." These "langas" are frames constructed for the purpose of drying the corn. They consist of wooden poles placed at equal distances apart, and supporting cross beams of wood, which are again crossed by others. On this frame the sheaves are placed; they remain for about a month, and then the ears are removed to the granaries. When required for use, the corn is thrashed by women, who beat it with sticks over a basket. It is then winnowed. Dokn is thrashed in a different way; the ears are placed in a tall wooden tub, and beaten with a pole, much like our dollying. The corn is ground between two stones, like the Egyptian mohakka. One very large heavy stone is placed on the ground and chipped with a small one till it is flattened, then it is rubbed smooth with another stone, the process occupying two or three days. A small oval-shaped stone is used for grinding the corn upon the large one.

Land.—The acquisition of land appears to be an easy matter. It may be obtained from a neighbour by mutual arrangement, or by reclaiming it from forest or jungle. A piece of land once appropriated descends from father to son, and the chief of the tribe has no right to any but his own landed property. No definite boundaries exist to mark the limits of villages or districts; but a sort of indefinable understanding appears to obtain. Landmarks may be seen dividing strips of land owned by different people in one village; they consist of large stones placed at intervals of about 100 yards. Hedges are unknown, and no corresponding protection is found necessary to ward off wind.

Plots of land are protected from depredation by watchmen. Pits and traps are also made to catch elephants, buffaloes, and gazelles. These larger animals are, however, not so troublesome as ants and mice, which often eat the corn. It is also frequently injured by the intense heat of the sun, which shrivels it up before it is ripe.

Crops are grown on the same plot of land for several years running, and often twice in a year. When at last the produce yielded begins to degenerate, the ground is left fallow for a year or two.

Migrations are frequent, as the result of a discovery of good soil; sometimes a whole village will migrate to a new place. On such occasions the people may be seen flitting by small companies at a time, about ten men leaving at once, making a sufficient number to carry the wooden framework of the roof of a hut, which they take with them.

The only exportation consists in corn being sold or given to neighbouring tribes when they are suffering from bad crops.

Measurements of an Average Man.

No.		
1.	Height from ground to vertex, ...	161·5
2.	Greatest breadth from glabella backwards, . . .	19·0
3.	Greatest breadth above ears, ...	14·7
4.	Length of face from root of nose to lower border of chin,	11·5
5.	Breadth of face from one foremost under edge of cheek-bone to other, ...	11·3
6.	Breadth of face from one angle of lower jaw to the other,	11·4
7.	Greatest breadth of zygomata, ...	12·
8.	Length of nose from root to junction of nose and upper lip, ...	4·7
9.	Height of head from chin to vertex, ...	21·2
10.	Length of neck from Adam's apple to sternal notch, .	6·7
11.	Length of body from sternal notch to pubes (upper edge),	50·0
12.	Length of navel from ground, ...	99·5
13.	Length of upper edge of pubes from ground, . .	84·2
14.	Height of head from meatus auditorius to vertex, . .	11·8
15.	Distance between two ears at top of opening of meatus auditorius, ...	13·5
16.	Upper breadth of nose from one canthus to the other, .	2·9
17.	Lower breadth of nose on cheeks, ...	4·3
18.	Length of nose from root to lip, ...	4·4
19.	Breadth of mouth, ...	5·2
20.	Distance from meatus auditorius to junction of nose and upper lip, middle line, ...	12·3
21.	Distance from meatus auditorius to root of nose, . .	13·7
22.	Distance from meatus auditorius to middle of upper lip,	14·8
23.	Distance from meatus auditorius to chin, lower edge, middle line, ...	14·5

No.		
24.	Greatest circumference of head at glabella,	54·5
25.	Arc from tragus to tragus over top of head,	34·0
26.	Circumference of chest just above mammæ,	84·6
27.	Distance between nipples,	20·1
28.	Breadth of shoulders across back,	34·7
29.	Circumference of waist at navel,	66·1
30.	Breadth of haunches,	27·9
31.	Length of arm from shoulder to tip of middle finger,	74·2
32.	Length of arm from shoulder to condylus external osis humeri,	30·5
33.	Length of arm from olicranon to end of ulna,	28·0
34.	Length of hand, wrist-joint to tip of middle finger,	19·4
35.	Length of leg from trochanter major to ground,	87·0
36.	Length of thigh from trochanter major to condylus external osis femoris,	41·2
37.	Length of leg from condylus external osis femoris to external edge of external malleolus,	41·2
38.	Length of foot from os calcis to tip of great toe,	24·6
39.	Arc from root of nose to union over head,	31·9
40.	Circumference of neck, maximum,	33·8
41.	Circumference of thigh, „	49·8
42.	Circumference of calf, „	35·3
43.	Circumference of arm, „	27·9
44.	Circumference of forearm, „	25·9
45.	Circumference of haunches, „	80·2
46.	Circumference of trochanter, „	
47.	Span of outstretched arms, „	155·7
48.	Span of thumb and mid finger,	17·3
49.	Length of thumb from second joint to tip,	3·5
50.	Greatest breadth of head from chin upwards and backwards,	24·0

Pulse, 68. Respirations, 20. Temperature, 97°·5. F.

Table of Principal Indices.

Cephalic Index.

$$\text{Measure } \frac{\text{No. } 3 \times 100}{\text{No. } 2} = 77{\cdot}91\,.$$

Nasal Index.

$$\text{Measure } \frac{\text{No. } 17 \times 100}{\text{No. } 8} = 91{\cdot}48\,.$$

Facial Index A.

$$\text{Measure } \frac{\text{No. } 4 \times 100}{\text{No. } 5} = 101{\cdot}7\,.$$

Facial Index B.

$$\text{Measure } \frac{\text{No. } 4 \times 100}{\text{No. } 6} = 100{\cdot}8\,.$$

Facial Index C.

$$\text{Measure } \frac{\text{No. } 4 \times 100}{\text{No. } 7} = 92{\cdot}0\,.$$

Skin dark brown. Iris brown. Conjunctivæ dirty orange-yellow. Palms and soles lighter shade of brown. Teeth good; none removed. Well nourished; not tattooed. Hair short, crisp, curly black. Slight down on upper lip, none on other parts of body. Not circumcised.

Eyes between 1 and 2 Broca's Table, only deeper. Darker when out of health.

Skin between 27 and 42, colour varies; but is lighter in shade than the hair, and has a more reddy hue.

Hair (41 Broca's Table).—The hair is extremely frizzly, fine in texture, and abundant, and grows in spiral tufts, the roots being equally distributed over the head, but thickest at the top. It appears to be capable of growing to a considerable length, its growth being favoured by a very free use of grease (without which it dries and comes out). The men allow their hair to grow about 6 inches, *i.e.*, when untwisted and measured. The women wear their hair rather longer, and with them the hair is trained to hang down; the men's, on the other hand, is more upright. When it has grown to these lengths they shave it entirely off. In shaving, some people leave a narrow ring of hair all round their heads like a crown; others leave three or four tufts, according to the tribal number; others again leave a great many small tufts growing. This is a fanciful arrangement, and has no particular signification.

Dyeing the hair is not practised. Baldness before old age is very uncommon. The hair is rather darker in colour than the skin; it turns grey about middle life. Only women practise the art of shaving; they make it a profession, and unite with it the extraction of teeth; the four upper and lower incisors being extracted from both sexes alike at puberty. A curved knife is used for shaving, the outer edge being sharp. Having placed the man's head in her lap, the barber proceeds to cut off the tufts of hair, she then squirts milk from her own breast on to the scalp, rubs it well in, and applies the razor. Scissors are unknown. The eyebrows are also removed, as is all other hair found on the body. The hair from the upper lip and chin is often pulled out by the roots. Sometimes very old men will permit a few white hairs to grow on the chin. The women are paid for their services with an arrow.

Odour.—Notwithstanding their frequent ablutions, the Madis have an odour peculiarly their own. It cannot be said to be produced by dirty habits. It is always present, is varied by the oil and fat with which they anoint themselves, and is much intensified by muscular exertion, *e.g.*, running, carrying loads, &c.

Clothing.—The Madis do not wear any clothes, unless the word can be applied to a string which the women put round their waists, and from which hang a few leaves before and behind.

Physical Powers.—With regard to the physical powers of the Madis I can only give some very general notes, as I was not able to put their strength to the test with any amount of accuracy.

The following remarks will give some idea of their strength :—

They make admirable porters, being very careful of the loads entrusted to them, and display no little forethought and ingenuity in preserving them from injury. The rule is that no load should exceed 50 lb. in weight, and that it should be either square or oblong, the latter being preferred. They always carry the load on the head, on a pad made of grass, very rarely steadying it with the hand unless going over very rough ground. They strongly object to carry loads over 50 lbs.; but if pressed will take them up to 70 lbs., if the distance to be marched is not more than three days, and extra food is given them.

Loads of 100 or 120 lbs. are carried by two men, hung on a pole, which they balance on their heads ; but they do not like the work. If a very heavy load has to be carried, *e.g.*, a man, they place him on a native bed and carry him, two at a time, changing relays of men at about each mile. This they prefer to carrying by four men at once. I can testify from personal experience that it is far better to be carried by two men than four, for they go much more easily, and do not run against so many trees or overhanging branches. The relief men march before those who are bearers, and cry out when obstacles occur.

As regards distance, they carry loads of 50 lbs. 20 miles a day, for eight or ten consecutive days without showing signs of distress; but on the march they appear to require a great deal of water, and will sooner burden themselves with a gourd full than go without it for more than two hours at a time. If they go by a road where water is scarce, they generally take a few women or children with them to carry it. When they arrive at a stream, all loads are put down, and they bathe if the water is deep, or sit down and wash themselves if it be shallow, and then take a long drink. Europeans would probably prefer to drink *first!*

The Madis can scarcely ever be prevailed upon to march at night, even in bright moonlight, on account of bad roads, which is strange, as their eyesight is remarkably good. Neither will they start until the dew has disappeared from off the grass, or if made to do so by promises of reward they tie bunches of grass or skins before them, to avoid as much as possible being wet by the dew. In crossing a river of four or five feet deep, they stand in the water in a double row, and hand the loads from one to the other. Should the stream be very strong, they break down branches which have broad forks, and placing one end firmly in the bed of the stream, lean against the fork, and so get the needed support.

They march at a quick pace, but generally halt for 10 or 20 minutes after each three or four miles. Should heavy rain come on they like to stop and shelter themselves and their loads under quickly improvised shelters.

In carrying the Egyptian post these men make long and quick marches, 60 or 70 miles often being accomplished in twenty-four hours.

Pathology.—The Madis are a healthy race, and do not suffer very much sickness. Coughs occur during and after the rains, but very few people die of pulmonary complaints.

There are male and female doctors, but the males confine their practice to wounds, accidents, and snake bites, and do not receive payment, but have their food given to them when they are attending a case.

Wounds of the extremities heal very quickly. They are washed and covered up with a paste made from the roots of shrubs, ground and mixed with a little cold water. Scalp wounds give more trouble, often suppurating, and at times causing death. Wounds of the chest are not much feared, but when they occur in the abdomen they are almost always fatal.

The people suffer from abscesses, which are opened, well washed with water, and then dressed with the above-mentioned paste.

Hydrocele is not as common as among neighbouring tribes. They try to cure it by long-continued pressure of the hands, but without much success.

The treatment of a broken arm or leg is noteworthy. When it is a simple fracture, the limb is pulled as straight as possible, and then sticks are placed as splints to keep it in position, and are tied with cords. When the bone is broken in pieces and the limb swells, so that they cannot properly straighten it, a number of small cuts are made, and cupping horns applied. These horns are made of cows' horns. If when the swelling has been reduced they still cannot straighten the limb, they cut the broken bones out, and fix on splints, applying a powdered root to the wound. Hæmorrhage is stopped by actual cautery. This operation is rarely successful, as most people who undergo it die in a few days.

The doctors impart their knowledge to young men, but their own sons do not follow their profession.

If a man is bitten by a snake, the wound is well sucked or the parts scarified, and cupping horns applied if handy, and then a powdered root is freely applied. This root is very expensive, a cow being often given in exchange for a small quantity of it.

Women doctors treat all cases besides those mentioned above, and receive one cow, two sheep, or a bundle of arrows for their services. They have but few medicines, and seem to make frequent use of magic. When a women doctor is called to visit a patient she brings with her a basket containing what I may call her magic wand. It is a kind of double tube about a foot long, each tube being about 4 inches in diameter. The one tube is partly filled with smal stones, the other is empty, to allow of the doctor performing her manipulations in it. This instrument is painted red, and oiled all over. The doctor shakes the wand, and mutters to herself for some little time, then feels the patient all over and draws her wand over him. When pain is complained of in the abdomen or chest, she first rubs the part with oil, and then places her wand over the painful spot, introducing her hand into the empty tube. After working about for some time she at last draws out a substance which she calls the disease, taking care that the people shall not have any opportunity of seeing it closely. If pain is felt in the head, she cups the patient on the temples or nape of the neck by making small cuts with a sharp stone; an iron knife is not used. Cupping is also employed for very severe pain in other parts of the body.

These women doctors appear to be generally right in their prognosis. When their work is over they are always accompanied home by the head of the house (see *Odi* for the treatment of children).

Medicine is given internally for fevers, which are generally caught through bathing or getting wet after sunset. An infusion is made from a root after it has been dried and scraped, and this is drunk by the patient at frequent intervals. Profuse perspiration results after a few doses. Toothache occurs in old people, but only rarely are caries seen. They do not extract the tooth at once, but loosen it gradually by working it about a little each day until it comes out.

Epileptic fits would seem to be of rare occurrence, as I could not hear anything of them.

Small-pox occurs in epidemics; great numbers of the people die from it; and it is rare to see a person pitted, as only very strong constitutions recover. When a man is attacked by it, he is placed in a hut which has a sand floor, and a large fire is made in it to keep the patient very warm. Meat is never given him, and only a small quantity of food, such as thin porridge. When the pustules are well formed they are all opened with a thorn, and then an infusion of roots and leaves is given to the patient to drink twice a day.

The people are very particular to rub their bodies all over frequently with oil, for if this be neglected a scaly eruption results, which is, however, soon cured by an extra amount of oil.

As yet there is very little syphilis in the country, but it is gradually making its way from the north and east.

There are very few dwarfs; they are considered to be great curiosities, but are not ill-treated. Hunchbacks are more common, and occur in about equal proportions among men and women, so far as I could discover.

Marriage Customs.—The Madis are not allowed to marry amongst their own friends, but generally obtain wives from neighbouring villages. Just about the time when a young man arrives at puberty his father makes a tour of the surrounding villages in search of a suitable bride for his son. Having found one to his mind, he ties a twig of a certain tree round her wrist, usually the left one, and then seeks her father's permission for her to marry the youth. If the price to be paid in cows and sheep can be amicably settled, there is seldom any further difficulty in obtaining his consent.

If a young man meets a girl during his travels and she takes his fancy, he is at liberty to ask her to marry him, and if she is willing he ties a twig round her wrist. She then goes home and tells her mother what has taken place, and the mother informs the father, who sends for the young man, and if he approves of him, gives his consent to the union, at the same time stating the price he wants for his daughter. The young man has then to obtain his own father's permission. He tells him of his choice, and the price to be paid for her, and as a rule the father does not withhold his consent. The news is then published abroad that So-and-so's son is to marry So-and-so's daughter, and so much is to be the marriage portion. Should the parents not come to terms, the marriage does not take place, for the young people must always obey their parents in this matter, and runaway matches do not occur. Both young men and maidens appear to be faithful to their choice, and I have not been able to hear of a case of jilting.

Before the marriage takes place, the young man may go and see his fiancée whenever he likes. Meanwhile he works hard to get together as many cattle and as much grain as possible, to enable him to begin housekeeping. When he has passed the age of puberty by a year or so, the girl being also of a marriageable age, their friends are informed that the wedding will soon be celebrated.

The girl's father builds her a new hut, into which she goes a few days before the marriage ceremony takes place. The dancing ground is also swept and made ready.

The young man, on his part, collects together the cattle to be given for his bride. His friends all make him presents, the most substantial help coming from his father, mother, and father's brothers. The payment must be made in cows of one year old, or bulls of two or three years, also one one-year-old fat cow as an extra gift for the feast to take place at the bride's village.

On the morning of the day on which the ceremonies are to begin, a band of youths proceed from the bride's village to the bridegroom, who hands over to them the stipulated number of cattle. Each youth leads one cow by a rope tied to its leg, its neck being ornamented by a garland of leaves. Thus they are taken to the bride's father. A group of unmarried girls, from the bridegroom's village, accompany the youths, and the bridegroom's brothers and sisters make up the party. Should he be an only child, two of his best friends or unmarried relations join the band. He himself remains behind. On their arrival the cattle are counted before the bride's hut, and if found correct as to number and quality, as is usually the case, they are sent to the cattle pen, but are not mixed with cattle belonging to the bride's father, which are previously removed to a distance. Should the tale not be correct, a messenger is sent to the bridegroom's village, if it be near, to fetch the remainder; but if at a distance, the ceremonies are delayed a day, or may be more. This mishap, however, rarely happens, as care is taken by the bride's father that the right number of youths are sent, and the bridegroom is particular to provide the corresponding number of cows, so that mistakes are usually avoided.

The fatted cow is killed by the bridegroom's brothers in front of the bride's hut, and their cooking operations commence and a great feast is held, after which dancing takes place. Very often nothing but water is drunk at the feast; and if beer is provided it very rarely, if ever, leads to drunkenness. During the feast and subsequent dancing, which lasts two days, the bride is not allowed to leave her hut; but she is not left quite alone, as her future brothers and sisters-in-law keep her company, and expatiate meanwhile on the virtues of her future husband, and the delights of married life. They also fetch her food, but retire while she eats, as it is not proper for them to see her at her meals.

On the third day there is another feast, on which occasion the bride's father provides the cow, and dancing follows as before. Then the bride, for the first time, leaves her hut, and goes to the dancing ground, accompanied by her brothers-in-law, who walk one before and one behind her. They proceed to the centre of the dancing ground, round which an assembly of spectators sit or stand under the shade of the trees. The brothers-in-law then retire to a short distance from the bride; she is welcomed by a loud shout, and then begins to dance the particular marriage step, which lasts a long time, and is accompanied by special music and clapping of hands. The longer she keeps on dancing the more creditable it is to her. It is a proud time to the lady, and she takes great pains to show off well, and to please the spectators. Afterwards she retires to her hut, and word is sent to her bridegroom that she has acquitted herself well. The next day she rests after her tiring exertions, and the day following the bridegroom arrives, attended by his unmarried friends of both sexes, relieves his brothers of their charge, enters the hut, and claims his bride.

The happy pair remain eight or ten days together in that village, being supplied with food by friends, who also fetch them water and firewood, in order to save them trouble. During this time the father of the bridegroom is engaged in constructing for his son a new hut, and on the eighth or tenth day the newly-married couple come and pay a visit to it. A sheep is killed at the door, after which they enter over the body and blood of the animal. The bride is then only presented to her father and mother-in-law, and remains there two days, but never eats in the presence of her husband's parents. The young couple return to the lady's village, re-occupy her hut, and remain there a variable time—until, in fact, the lady is in an interesting condition. As soon as this occurs, they return to the husband's hut, and settle down to their usual pursuits.

Divorce is not common, and if a woman is barren it rarely occurs. It may, however, take place if a wife makes herself disagreeable to her husband, friends, and relations, and also if she should prove unfaithful; but this is a rare occurrence. Should divorce take place for any just cause, the wife is sent back to her father, and he refunds the greater part of the cattle, the number varying according to circumstances.

If a wife wishes to visit her friends or relations at a distance, her husband accompanies her, and fetches her back at the end of the visit.

Polygamy is permitted, but is not very common, and seems to be regulated more by a man's wealth than anything else. The greatest number of wives allowed appears to be four, and a long period (two years?) elapses between each new marriage. Each wife has a separate hut, and the husband passes a definite number of days with each in rotation. This is regulated as circumstances may require, but each wife expects her full allowance. When this is granted, as it usually is, the wives live on good terms with one another.

Should a woman who has a child be divorced, if the divorce has been for her adultery, after the child is weaned it belongs to the husband; but if she should be divorced from any other cause, she keeps the child. In either case, the father and mother can visit the child, or it may go on a visit for a few weeks to either parent. Women who have been divorced may, but seldom do, marry again; should they do so, they are to be had cheap, and the children, if there be any, from the previous marriage remain with the grandfather. The Madi women generally make very good wives, and married life is apparently a smooth one. Prostitution in a general sense is unknown. Before marriage the girls are very carefully looked after, but as marriage usually takes place very early, there is not much cause for them to go wrong. This also applies to the men.

Reproduction and Birth, &c.—Early marriages appear to be the rule, and, as before mentioned, polygamy obtains only to a limited extent. It is very difficult to give facts as regards the number of children born, &c., but a few notes may be of interest.

Four children would seem to be a fair average family. Few die directly after birth. Twins occur at times, and are considered very lucky both to the parents and to the village at which they are born. Many congratulations are offered, but no special ceremonies take place at their birth. I could not hear of a single case of triplets, but one woman was said to have had four children at a birth. Girls and boys are equally valued, but a boy is generally preferred as the first child.

As a rule, labours are very easy. As soon as a woman thinks that she is near her time of delivery, she abstains from meat, but eats a good deal of vegetable food. She gets a neighbour to help to clear out her hut, sends her children, should she have any, to friends, and when labour commences, she walks round her hut, while her friends place a deep layer of dry sand at a short distance from the door. Sometimes two good-sized stakes are driven into the ground, about

2½ feet apart; and the sand is banked up near them. The woman then sits down on a skin placed on the sand, puts her feet up against the stakes, and clasps her ankles with her hands, her arms being inside the knees. Her friends take it in turn to support her back, and at times aid her by pressing or rubbing the abdomen. Another friend squats down before her to receive the child as soon as born. The sand, of course, moulds itself to the woman's body, and being pushed down in front, might almost be said to support the perinæum. A fire is kept burning in the hut, and a very thin porridge is given the woman at short intervals. She keeps remarkably quiet, and often never moves from her first position until after the child is born, her friends keeping up all the time a low kind of chant, and doing all they can to encourage her. When the child is born, the cord is cut by a stone knife as a rule, but sometimes it is bitten. Should the cord bleed, the woman who has received the child takes the cord in her mouth and squeezes it with her teeth, so stopping all hæmorrhage. They never tie the cord. The placenta is buried in a hole dug outside the hut—that of the boys on one side, that of girls on the other. Still births are very rare.

When all is over, the mother is gently moved to the side of the fire, where she lies down on a bed made of dried grass covered with a skin. As soon as the child is born, it is cleaned by gentle rubbing, and then smeared with oil and wrapped up in a soft skin, after which it is shown to its father, grandfather, and other friends. In about an hour after birth it is put to the breast. The mother gets about again in three or four days. She then sits with her child in the door of her hut, and receives the congratulations of her friends. The woman is not allowed to eat meat for about a week after her confinement.

On the occasion of a child's name being given it, a fowl is killed by the father and grandfather before assembled friends. They cut off the animal's head, apply some of the blood to the child, and pronounce the name. It is not at all uncommon for children to be named according to the season in which they are born—*e.g.*, Kranobu = famine; Kradaru = hunting season. At other times they are called after their deceased relations, rarely after living ones. Family names do not obtain, but a son bears his father's name in addition to his own; more frequently, however, pet names are used.

In this district women do at times bring forth their children on the march, and then continue marching; but this is by no means a frequent occurrence, and is guarded against as much as possible. I have known it happen on two or three occasions, but the result in one case was fatal to the mother.

When a hard labour occurs, and a woman remains a long time undelivered, so that her strength begins to give way, a man is sent for to deliver the child. He, however, uses no instruments; and should he fail, which, I am told, hardly ever happens, mother and child as a rule perish, for abdominal section is not practised here. Barren women are uncommon. Very few births occur out of wedlock, but I was not able to obtain much information on that point.

The women suckle their children about two years, but the period of their separation from their husband is only six or eight months. If several mothers are suckling at the same time, it is not uncommon for them to suckle each other's children; and I have once or twice seen a small child, who did not find sufficient milk in his own mother's breasts, toddle off to another sitting by and commence to suck away without rebuff. During lactation the breasts are of an unusually large size. After several children have been born they become very flabby, and hang down like long flaps of skin. A cord is then tied round the chest to prevent them flapping about and causing inconvenience.

When born, the babies are of a reddish tinge, and they get dark gradually. The women carry their infants in skins which have been dried in the sun and scraped clean and smooth with a stone, and softened with butter. The skins of goats, gazelles, sheep, and calves are used, the legs being tied together and strung over the mother's shoulders. The baby is placed in the skin under the woman's arm, with its head behind. Sometimes a gourd is placed over the head to protect it from the sun. When older the child is carried on the arm. Infanticide is unknown.

Education of Children.—A good deal of attention is paid to the instruction of children in matters of conduct. They are taught to behave well at meals, not to put their hands into the dish till after their elders have helped themselves, to rise as soon as finished, and having washed their hands, to remove to a little distance. They are also taught to be quiet when older persons are holding a council or chat. They are made to salute people in passing, and to show kindness to the aged and to the sick.

The girls are taught to cook, to sweep out the huts (with bundles of fine dried grass), to show hospitality to strangers, to fetch water and firewood, to elude arrows at a fight, to dance, and to perform "Ionian" movements. The boys are taught to shoot, to fight (blunt arrows being used), the proper way to treat an enemy, &c.

The education of boys and girls is not considered to be complete until they have travelled. When about ten years of age they are sent away from home to visit friends and relations at distant villages or among neighbouring tribes. They remain away during the fine months of the year. The girls may return at any time, but the boys are usually anxious to remain away as long as possible, in order to learn as much as they can from contact with other people. Should the girls wish to come home, the boys will bring them, and as soon as they have seen them safe with their relations, they start off again. The boys must, however, return home when the rains begin, and remain during the wet months, to help their fathers in agricultural work; whereas the girls, if they choose, may stay away; if wanted, they are sent for. When out on these visits the young people take part in the hunts, dances, or whatever else may be going on. Sometimes a father will take his children a round of visits.

Both boys and girls are taught to find their way about, so that if the path should be lost they are not long in discovering their whereabouts.

Family Gatherings.—There does not appear to be any special occasion for family gatherings, but from time to time all the sons, daughters, and grandchildren meet at the father's house. The love for children causes great interest to be expressed about the babies. At such family gatherings the father directs the thoughts of all to grandparents and old friends who have passed away, enforcing at the same time the duty of attention and care to relatives and friends when ill, and of mourning for them when dead, as they then are beyond the reach of help.

Tribal Signs.—Each division of the tribe has a number, by which those who belong to it are known. Persons are said to carry so many stones, but this is merely a form of speech, as the stones are not literally carried. The lumps of earth thrown into a man's grave correspond to his number of tribal stones, and in this way also will a man often regulate the number of tufts of hair to be left on his head after shaving.

Burial Customs.—Immediately it is known that a man is fatally wounded, the news is sent to his wife, who hastens to him, taking their children with her. A touching scene is witnessed when they reach the dying father. The little children are placed upon his knee, and the others stand round about him, while he gives them his "blessing" by putting his hands on their head and moving his mouth as if spitting. After telling them to be good, and not to grieve too much for him, he solemnly addresses his eldest son, giving into his charge his mother, brothers and sisters; also the fields and cows. He also is careful to tell him through what tribe he has met with death, in order that his son may some day revenge him by killing one or two men of that tribe. Then follows an affecting farewell to his wife. If he is a well-known man, and not far from his home, a great company of his friends and acquaintances gather round to take leave of him. While the body is being carried to his hut, a drum is sounded as an intimation that he is dead. This is also done at the hut if a man dies at home, and is repeated at the burial. The body is usually buried one day after death, close by the man's hut, but sometimes by his father's.

A deep round hole is made in the ground, and at the bottom of this a deep recess is scooped out. In this recess the corpse is placed, being laid on the right side with the head leaning on the right hand. Lumps of earth are then thrown into the hole by the children, first with their backs towards it, and then their faces, the number of lumps coinciding with the number by which the deceased's tribe is known, the girls throwing one less each time than the boys. A pole or tree trunk is then fixed in the ground at the bottom of the hole, which is not filled up, but covered by two large stones placed against the pole. Sometimes there is no pole, if a stone can be found large enough to cover the hole. Over this is erected a conical mound of earth, three or four feet high, which is stabbed by flat stones. If a pole has been placed in the grave it projects above this mound, and is surmounted by the horns of cows killed by the grave. Four cows are killed by the friends out of respect for the departed, and the eldest son often kills his favourite ox.

If a great man has died, friends and relations come from a distance to the burial, and stay a few weeks (four?) mourning for the dead. For the first four nights they sleep on skins by the grave, and during the remainder of the time they pay frequent visits to it and make lamentations. The deceased's widow resigns all household duties to a sister or friend, and gives herself up to weeping during a month.

At the end of this time a lamb is killed; it is subsequently eaten by the friends, as were the cows killed on the day of burial. The son leads the lamb to the grave, but it is killed by a man of a semi-priestly order (whose office it is to perform such like duties on various occasions). This man, after killing the animal, sprinkles its blood on the people and the grave. After speaking at length on the virtues of the deceased, he sprinkles the people with water, exhorts them to put away their sorrow, and to show kindness towards each other. The friends then take their leave, but a year after the man's death all his relations and friends who live near meet again and celebrate the day by a feast and dance; and on these occasions the dance is never followed by a fight.

If a woman die her friends mourn her loss also for a month, but for children the time of mourning is only a few days.

If a man should be killed at a fight or hunt, and the place and manner of his death be unknown, his friends go and search for his body, and if they cannot identify it, they bury any bones they may find about the place of supposed death.

As soon as the period of mourning for a father is over, the children (if young) are taken to their father's family, and a consultation is held as to what is the best thing to be done with them. They are usually placed inside the circle of consulting relations, and if old enough are asked whether they will stay and live with their father's people, or go with their mother. The mother is urged to remain in the village, but she usually prefers to go to her own relations, and as a rule the children go with her. Sometimes the eldest son, if he is old enough, will remain on his late father's property and look after it, the mother with the rest of the children going, for a time at least, to live with one of her brothers. Later on she may return to her old home, or more rarely still she never leaves it.

Treatment of Superiors.—There appear to be no rules of precedence nor any difference in the treatment of rich and poor. The poor are generally those whose parents have died when they were young, or those whose father's cows have been stolen by an enemy. In this case the children are adopted by relations, and when they marry, a small number of cows are given to them as presents to start them in life.

Each village is quite independent, having a president or sub-chief at its head; only in time of war must the men from each village assemble, under the head chief, who resides in the largest town. The village head-men and even the chiefs are treated with great familiarity, no spirit of subjection or fear apparently existing.

Hospitality.—Hospitality is inculcated and universally practised to kinsfolk, neighbours, strangers and enemies.

A passer-by is invariably invited to share any meal which is proceeding, and a refusal to partake of the proffered kindness is considered as an offence. If he is in a hurry, and does not wish to be delayed, politeness requires him to dip his hand in the dish and to eat a mouthful before proceeding on his way. At a meal the guests sit on the ground, and help themselves out of the common dish. Water is brought them to wash their hands, children performing this duty. Water is always at hand to offer to passing travellers. Every family has a hut for the special use of visitors, and if guests arrive unexpectedly when the hut is already occupied, the children are turned out to sleep at a neighbour's, and their hut appropriated to the visitors.

Treatment of Women.—Women are treated with respect and politeness by the men, who always show them preference, resigning to their use the best places, and paying them such like courtesies. They eat at the same time, though not out of the same dish as the men; but associate with them on equal terms, being consulted and honoured. Any insult to a woman is revenged, and is frequently the cause of war. Drunkenness is very little known, but in the case of a man becoming intoxicated, and in that condition insulting a woman, he is punished by being tied up until perfectly sober.

Treatment of the Aged and Infirm.—In the training of children, obedience and great respect for parents and elders are inculcated.

Great care and attention are paid to the aged, and counsel and teaching from them is considered of special value. The sick and infirm are cared for and nursed with much solicitude. Much affectionate care is exhibited by husbands to their sick wives.

Communications.—The construction of the roads is very simple, a track of some two feet wide being formed by merely cutting down the underwood of the forest. More than this is not attempted; a network of small paths in the forest being made by use. Swamps are usually passed by wading, although occasionally a way across them is made by filling in with stones, sticks, and grass.

Rivers are crossed by swimming, an art which is learnt very early, as is also an acquaintance with the haunts of crocodiles and hippopotami and the shallow parts of the rivers, so that should a man be carried down by a swift current he is quite at home, and knows where best to make for land. Boats and even rafts are unknown, but bridges are occasionally constructed over rivers, and are made as follows :—Trunks of trees are firmly fixed in the bed of a river in the dry season, being supported by stones, and having forked tops along which is laid a single row of logs—thus forming a simple kind of bridge.

No accommodation is provided for travellers between villages; they rest where rivers or wells supply them with water, and then continue their journey till a village is reached.

On a journey, if a man cannot find a stream, he digs for water in the ground; and the wells thus formed last for a time, and serve for the use of other travellers.

When a village is reached there is no lack of accommodation, hospitality being universally shown alike to friends and enemies. Immediately a stranger is seen, he is asked how many stones he carries (see *Tribal Signs*). If the man who accosts him is of the same number, they fraternise directly; but in any case, the stranger is escorted round the place to see all there is to be seen, and a hut and food are given him.

No vehicles of any description are used, the only mode of conveying persons who are too old or too ill to walk is by means of a kind of litter made of branches laid side by side, and fastened together on to cross pieces of wood. Upon this rude contrivance the individual lies or sits, and is carried by two or four men.

Horses are not known, nor are any animals used as beasts of burden; but their need is little felt, as the necessaries of life are very few. Heavy weights, such as animals or fish, are often slung on a pole, and carried between two men; while trunks of trees are transported by the simultaneous efforts of men, pulling to the sound of their voices.

It is customary for meeting travellers to exchange greetings, a phrase answering to our "How do you do" beginning the conversation. The young are carefully instructed by their elders to show a friendly spirit even towards an enemy if met on the road, unless he should appear to be bent on insolence, in which case high words are to be returned, and they are frequently followed by violence.

It is not necessary to obtain permission before passing through the territory of another tribe; and even if travelling among a hostile tribe, a man is unmolested unless he himself provokes attack.

When a man encounters a stranger on the road and is accosted by him, he stands in the usual position of ease (the right foot resting on the left calf), with his bow and arrows in the left hand, and talks to him in a friendly manner, at the same time on the watch for lurking enemies. If the traveller prove to belong to a hostile tribe, and become insolent, the pleasant tone must not be maintained (it would be taken for cowardice or fear), but he must be met with "flashing eyes and angry expostulation;" should he wax more angry, and use insulting language about the man's mother, a fight is unavoidable. In this case it is possible that others (friends of the stranger) will be in ambush near, and at a given signal will surround the man, so that for a long time he must try by great agility to avoid their arrows. There is a leaf which is believed to possess peculiar virtue, and if any of it is at hand the man will endeavour to seize some of the leaves and rub himself with them. He then aims at the stranger who accosted him, and if possible shoots him. If he is successful in killing his assailant, he may escape if he please; but to do this is considered a disgrace unless he has killed his enemy, or at least one of his tribe. Should the man be completely outnumbered, but contrive to escape, he summons assistance by means of his horn, and then, reinforced by others, returns to the scene of conflict, and should the enemy still be there, the fight is renewed.

It is usual for young persons to travel over the surrounding country often to considerable distances, and thus they acquire a practical knowledge of the country, and without the help of milestones, sign-posts, or other landmarks (all of which are unknown), they become expert in finding the way from place to place.

Salutations.—The modes of salutation coincide almost exactly with our own—greeting being expressed by shaking of the hand and kissing. Members of a family kiss, but the boys shake hands with their father and each other. Husbands kiss their wives and female relations, and friends kiss each other. Matutinal greetings are usual. Great joy is manifested at the return of a member of a family from a long absence, the brothers and sisters running out to welcome him; and frequently a lamb is killed as an expression of joy, and great virtue is believed to be in the blood, some of which is put upon the returned traveller.

Swimming.—Swimming is practised by both men and women in the Madi tribe, and the art is acquired very early in life. It is put to practical use by crossing rivers, fishing, &c. They do not take a header into the water, but simply walk or jump in. Diving is not practised. They swim as a rule hand over hand, and splash about and make as much noise as possible to frighten away crocodiles. Sometimes they carry children on their backs when in the water. They have a habit of taking in mouthfuls of water and spitting it out forcibly when in the act of making a stroke. On coming out of the water they rub themselves all over with their hands, to get rid of as much water as possible. If near home they rub themselves with oil after bathing.

Bathing and Cleanliness.—The Madis bathe each day in a river or other water near their homes; small children wash themselves at home in large earthenware jars. No soap is used or any substitute for it. They have no sponges. They always rub oil over their bodies after each bath. When they cut their nails, they bury the parings in the ground.

Division of Labour.—In the division of labour the woman's sphere is at home. She may help at times in the lighter field work in the cool of the morning, but must return home before the middle of the day, the men continuing at work. If, however, a woman has a family of young children to look after, she seldom leaves home at all. Her duties are domestic; she lights the fire, sweeps out the huts, fetches water twice a day from the river or well, makes butter, stores the food in jars, and cooks, &c. Children are early taught to be useful in helping their mother; and should she be ill, the husband fetches the water, lights the fire, and a neighbour is called in for aid, as the father cannot cook. No one is paid for such services any fixed price, but some present is as a rule given. The women attend sick persons with much solicitude.

The man's work consists in hunting, fishing, agriculture, procuring wood for bows and arrows, and firewood. He partly makes the bows, milks the cows, and sometimes helps in making the butter. The men also build the huts. When removing from one place to another the men carry all the heavy things, as well as the roofs of the huts, and fix them before they fetch the women. In hunting expeditions the women carry water in small jars for their husbands.

Religion.—With regard to the religious beliefs of the people, I have not been able to ascertain much, their ideas being so vague that a much longer sojourn among them than I made would be necessary to discover what is really or partially believed by them. They appear to have an undefined belief in a great Being who made the world and men. They also believe in "isa" = the soul or thinking part of man, which however perishes with his body. There is no belief in a resurrection or after life for man, though ideas and speculations on the subject are indulged in.

The first man is said to have come from the sky, but departed friends are thought of as being under ground, and their bodies are thought to turn into white ants, or to grow up as grass, mushrooms, &c.

I have been told that sometimes people imagine they hear their departed friends speaking to them, and that when they look to see the familiar forms nothing is visible but smoke. When this happens there is a general lamentation among the friends of the departed, and a lamb is killed and its blood is sprinkled on them all.

One man, tradition says, dreamt that his "isa" (soul) left his body sleeping, and went up to the sky. It is a common thing for lost friends to be seen in dreams, and to seem to turn into lions or some other object of terror. However vague their notions of a Deity or of themselves as spiritual beings may be, they teach and practise very sound principles of good.

A *good* man to them is one who is brave and not afraid to fight or die, who seeks the welfare of others, and is always ready to show kindness to them, who respects the aged, helps the sick and infirm, and gives to those who are in need.

Superstitions.—Among the superstitious practices in vogue in the Madi tribe, is the detection of guilt by ordeal.

Three means of trial by ordeal are used, through which it is believed guilt can be detected. If a man is accused of an offence and denies it, he goes with his accuser to have the matter settled by ordeal.

In one mode of trial they both receive a red feather of great value, and have to bite it through. This is considered very dangerous, for after a few weeks the guilty one will fall ill and die. Unless very sure of their own innocency they rarely try this ordeal.

At other times seed is given to be eaten, which will be innocuous to the innocent, but fatal to the guilty. Another method is by throwing down small sticks of equal lengths. In the case of an innocent man, the sticks will fall against each other, standing up like the legs of a Gipsy table, whereas a guilty man's sticks fall flat. Before any of these trials the men look up and solemnly invoke some invisible being to punish him if guilty, or help him if innocent.

If a man is seen committing an injury and does not deny it, the injured person challenges him, and they fight until one is killed or badly wounded. Sometimes the men of the village come together and separate them, and then a kind of rough trial takes place, and the defaulter is obliged to make restitution in kind, *e.g.*, a cow and a goat for a cow injured, a hut and a cow for a hut, &c.

There are three classes of men who possess authority in villages and districts. Class A. preside over ordeals; class B. possess the power to try persons accused of murder or any great crime; and class C., perhaps the most important of all, consists of the men who kill the lambs on particular occasions, as described elsewhere.

Madmen are always hanged. If birds afterwards feed on the body, it is taken as a proof that the person was really mad, their absence showing that he was wrongly put to death.

Great faith is placed in the power of a certain plant, a piece of which, after being spit upon, is applied to a man's shoulders and legs, and is believed to strengthen him, to preserve him from danger, to make his enemy "see crooked," or to enable him to slip out of his hand, just as the stem of the plant slips like soap when it is grasped. With this idea mothers frequently apply this plant to their sons. Sometimes also they sprinkle the boys with water, with a similar notion.

Omens are believed in. One of the most common is sneezing; it appears to forebode good or evil, according to what is being said at the time, producing a contrary effect to what is expected. Tripping one's foot against any thing is considered ominous. To trip on the same foot twice on the same day is a bad sign, once on each foot is a good one. Some people consider one of their feet lucky, one unlucky. It is thought to be unlucky to return by the same road that a man goes by, both for long journeys and short walks; a different route is always chosen when possible.

Odi.—There appears to be a belief in the existence of elves or spirits, though this would seem to be an invention of the female doctors to gain a hold on the people. "Odi" is the name by which these beings are known. They are supposed to live underground, and their help is sought in cases of illness among children.

If a child is ill, the lady doctor first examines it, and then retires to a quiet spot at a distance from the hut, where she erects a miniature hut of sticks and grass. She is followed to this place by the mother and one of her little boys, laden with a pot of food and a live fowl. She then proceeds to invoke the Odi to appear, but often gives out that they cannot come till the next day, being busy. At last they make their appearance inside the small hut, but are visible to none but the doctor, others only hearing them speak. Two usually appear, a male and a female, more than that number refusing to come at once. The doctor says they have human faces and serpent's bodies. She pretends to give them food to eat out of the pot, and asks their aid towards the sick child's recovery, shaking all this time her magic wand or rattle. When they have had enough food they vanish, and the doctor falls down right over the small hut. She strikes the ground with her hand, and appears to have a fit, unconsciousness lasting a few minutes. Before falling she tells the mother and boy to run home as fast as possible, and shut the door. A strong women is always present at this incantation, who is ready to raise the fallen doctor, and give her water to drink. After she has recovered from her real or supposed exhaustion, she is supported to the sick child's hut to see her patient. Before the door is opened a certain formula is gone through, after which she enters the huts,. feels the child all over, and gives her opinion as to whether it will get well or not. She is then escorted home by the father, who takes with him her fee, in the shape of a goat, cow, or arrows.

The Custom of Killing a Lamb.—A remarkable custom is observed at stated times—once a year, I am led to believe. I have not been able to ascertain what exact meaning is attached to it. It appears, however, to relieve the people's minds, for beforehand they evince much sadness, and seem very joyful when the ceremony is duly accomplished.

The following is what takes place:—A large concourse of people of all ages assemble, and sit down round a circle of stones, which is erected by the side of a road (really a narrow path). A very choice lamb is then fetched by a boy, who leads it four times round the assembled people. As it passes they pluck off little bits of its fleece and place them in their hair, or on to some other part of their body. The lamb is then led up to the stones, and there killed by a man belonging to a kind of priestly order, who takes some of the blood and sprinkles it four times over the people. He then applies it individually. On the children he makes a small ring of blood over the lower end of the breast bone, on women and girls he makes a mark above the breasts, and the men he touches on each shoulder. He then proceeds to explain the ceremony, and to exhort the people to show kindness, for example—

If rich, not to deny a cow or sheep to a poor man that asks one. If eating, not to appear unaware of a passer-by, but invite him to share in the meal. If children see a stranger, they should run to their mother for water to offer to him; or if they see an old woman fall, they should not laugh, but give her assistance.

When this discourse, which is at times of great length, is over, the people rise, each places a leaf on or by the circle of stones, and then they depart with signs of great joy. The lamb's skull is hung on a tree near the stones, and its flesh is eaten by the poor. This ceremony is observed on a small scale at other times. If a family is in any great trouble, through illness or bereavement, their friends and neighbours come together and a lamb is killed; this is thought to avert further evil. The same custom prevails at the grave of departed friends, and also on joyful occasions, such as the return of a son home after a very prolonged absence.

Harvest Feasts.—A harvest feast is held as soon as the corn has been reaped and placed on the "langas" to dry. It is then too that the general holiday time commences; there is very little work done from this period until the rains begin, hunting, dancing, and fighting occupying the interval.

The harvest feast is held in each village, and is only attended by the inhabitants of the place. It takes place on the open space which is usually found in the centre of the village. At the conclusion of the feast speeches are made. It appears that one man presides, and after an opening speech by this president, women as well as men address the company. The old people are listened to with great respect, and give advice to the young. The belle of the village is reserved to make the last speech, after which all disperse.

The enthusiasm evoked by a favourite orator or palatable sentiment is expressed by clapping of hands; but weariness or impatience is merely shown by sullen looks, only those who are rude covering their faces with their hands.

Music.—The Madis are very fond of music, and have several kinds of musical instruments—drums, harps, horns, and flutes.

There are large and small drums. The small ones are made out of a tree, the trunk of which is more than a foot in diameter, and their length varies from 2 to 3½ feet. The block of wood is either hollowed out by fire, or more rarely by the knife. Pithon or goat skin is usually fixed over one end by means of wooden pegs. Sometimes, however, both ends are covered, and then the skins are caught together by long laces of hide. The larger drums are very different both as regards size and shape. Logs of wood about 12 feet long are hollowed out, and placed on four wooden legs, four handles also being cut out of the wood (see fig. 13). A narrow opening is left along the under surface of the block, and not covered in. The drum is beaten by large sticks, having a somewhat globular end. All drums are well warmed before use, and near the larger one a fire is kept burning during its use.

The harps are made as follows:—The half of a large gourd is taken and two round holes made in it, into which are fitted two upright sticks, which diverge a little from each other. They are united above by a cross bar, from which strings made of sinews or fibres are carried down, and passed through small holes made in the gourd, on the inside of which they are fastened to small bits of wood. When in use the gourd is placed against the belly of the player, and so acts as a kind of sounding board.

The flutes are made out of hollow canes, having eight holes and a mouth hole. They are held as in Europe. They also use rattles made of gourds, partly filled with dried dhurra or small stones. Small bows are used as musical instruments. They are strung with hair from a giraffe's tail; one end of the bow is placed against the teeth, and then the string is struck with a switch.

I fear it is beyond my power to describe the music produced by these instruments, but I can testify that on a moonlight night the melodies they give forth are very weird and yet sweet, and at times fantastic.

Dances.—The harvest feast is usually followed the next day by a dance—this being the first dance of the season. One of the larger villages is chosen as the scene of the dancing festivities, which are held in a large open space outside the village. Great numbers of people assemble from the surrounding country; and as most of the inhabitants have to be present on these occasions, often only the old and very young people are left behind in a village. The holiday makers are accompanied by their cows, and these are left to graze outside in the forest, boys remaining in charge of them. This is done as a precaution, for if the cattle were left unprotected, raids might be made on them by enemies.

The band consists of a large drum and several small ones suspended on a pole; horns and rattles are also used. The musicians are placed in the centre of the ground, being encircled by the dancers. The old people present stand round the ground, and clap their hands in time to the music. The young men are grouped together and the young women placed opposite them. The married women dance together, and the married men in a group by themselves.

The dancing is chiefly from side to side, not forwards. Sometimes, however, a young woman dances across, and invites a young man to advance into the centre and perform a *pas seul;* and when he has finished, he in his turn asks a young woman to exhibit her skill, but they do not dance together. The men paint themselves with various colours for these occasions, and the women are adorned with brass necklaces, rings on their waists, arms, and ankles, and flowers round their necks.

Fights.—These dances are usually ended with a fight; in fact, it seems that the dance would not be supposed to have gone off properly without some such finale. The fight is begun in this way: A man shoots an arrow high in the air, so that it falls among the dancers, who immediately cease dancing, and range themselves into different sides, according as is their division of tribe. Then the game begins by a shower of arrows. The women remain with the men, carefully eluding the arrows; should a man be hit, some of his female relations rush up to him, carry him to a place of safety, and wash his wound. They do not try and stop the bleeding, for fear of causing inflammation. Should inflammation occur, light incisions are made to allow the blood to run freely. A special knife is used for this purpose. Should a woman be killed, there is great excitement, and the fighting becomes desperate. War goes on between the tribal divisions, until the offending one is considered to be sufficiently punished, and pays a large indemnity in cows. If no fighting is desired at the dances, all the bows and arrows are hidden.

Boys are early taught by their fathers the art of war, especially how to elude an enemy's arrow. This requires great dexterity and much practice, and young children are trained from very early days, shooting at their father with blunt arrows. The young men also instruct large classes of boys, and mothers train their daughters in the art of eluding arrows.

As in Europe, women at times take a dislike to one another, and very occasionally even come to blows. If they do, a very fierce and bloody encounter takes place, for the women, before fighting, put on iron bracelets with spikes both straight and curved projecting from them; with these they tear one another very badly. The Arab slave dealers do not appreciate these bracelets, and when in their raids they see a woman with them on, she is generally shot down at once, for at close quarters the Arabs are no match for them.

Weapons.—The weapons employed in hunting are bows, arrows, and spears; arrow heads have various shapes.

Arrows.—The heads are made of iron, and are barbed and ornamented. Sometimes they are poisoned for killing lions, &c.

The shafts of the arrows have a hole made at the top by a red-hot iron; into this the head is fitted and kept in place by flat iron wire; similar wire is also used to ornament the shaft. The arrows are notched, but have no feathers. The arrows used in war are made of the hard wood of the "pi" tree. The barb is also made of wood sharpened at both ends and fitted into the shaft. The end of the shaft is bound round with red string to prevent it splitting. In withdrawing the arrow from a wound the head is left behind.

Spear Heads.—These do not vary much in shape, but different sizes are made. Very large heads are used for elephants. The women, if on a long journey, carry small spears with ornamented handles. The spear shafts are tipped with an iron spike; both heads and spikes have a hole made in them, through which iron wire is passed to fasten them firmly to the shaft. No blunt-headed arrows are used, save those employed to instruct the children.

When hunting or fighting, the left hand is protected by a woven string "gauntlet"; it covers the palm of the hand and fingers, the thumb being left free.

Bows are made of several species of wood. The strings are formed of twisted tendons. Sometimes the bows are made quite plain, others are ornamented by rings of crocodile skin, but the middle of the bow is always left plain. One side of the bow is generally flattened, and there is enough difference between them for each man to know his own.

Animals speared or caught in pit-falls are as follows:—Rhinoceroses, hippopotami, giraffes. Animals shot with arrows: lions, gazelles, wild boars, leopards, foxes, elands, tetels, ostriches, buffaloes, baboons. Crocodiles are killed by a barbed spear, the iron head of which has a line attached to it, and is readily detached from the handle as soon as the beast is speared. Baboons are only attacked by a number of men together; it would be unsafe for a single man to attempt it. No nets, palings, or trenches are used in capturing game. There are no firearms in the country. Clubs are used; a favourite pattern is egg-shaped.

Animals.—The jungles abound in wild animals, the number and variety of which afford a wide field of sport for the hunter, and a choice abundance of food for the whole tribe.

The following animals are hunted, and all except leopards, baboons, and foxes are used as food :—Elephants, buffaloes, gazelles, rhinoceroses, hippopotami, crocodiles, wild boars, leopards, giraffes, elands, baboons, tetels, rabbits, porcupines, ostriches, guineafowls, wild ducks, pigeons, and various other species of beasts and birds which I am unable to identify.

The animals in a state of domestication are cattle, sheep, goats, dogs, and fowls. Fowls are fed with semsem and dhurra. A conical stone house is made for them close by the dwelling-hut, but no porches are provided. The people keep bees. The hives are made of basket-work, and fixed on the branches of a tree. The man who takes them up makes at the same time a sort of whistling noise, which seems intended to be a call to the bees. A hole is left at the bottom of the hive to allow of the bees getting in, and of the honey being subsequently taken out. To accomplish this a basket is pulled up, filled, and let down again, the use of a branch as a pulley being evidently unknown. Sheep and goats are kept in large numbers. Their sheds have wooden walls with thorns fixed on them, as a protection from hyenas, and they are roofed in like the dwelling-huts.

Gazelles and tetels are tamed when caught young, the former being fed on goats' milk and the latter on cows' milk. The tetels are kept for the purpose of milking. Rabbits are tamed, but not very successfully, as when they are full grown they generally manage to escape. Birds are not kept in captivity. The domesticated dogs are all smooth, and do not vary much in size, being about as large as our fox terriers. In colour they are either white, black, or brown, or black or white. They are intelligent, and show much affection and fidelity to their own masters. They are liable to hydrophobia, and when seized with it are at once killed. There is also a kind of wild dog, of smooth skin, reddish-brown colour, and a fox-like head and long ears. Dogs are the only animals which are trained. They prove of great use in hunting gazelles, buffaloes, and some small animals.

Horses are unknown, and only very recently have a few asses been introduced by the Arabs. There are no mule animals. Castration is not practised.

Two kinds of migratory insects visit the country. When the dhurra is ripe, green flies about 1½ inches long arrive in swarms; many are caught and eaten, and the remainder take their departure in the opposite direction from which they came. Swarms of locusts follow them. These are also eaten.

When they leave, a species of small red bird takes possession of the fields. They build their nests in the trees near the fields of the dhurra, and remain until the corn is too dry for them to eat.

Once a year the white ants swarm; when this is expected a fire is lighted near the ant hill, the ants are knocked down, gathered, preserved in jars, and much relished as food. Fleas and mosquitoes are very abundant.

There is no worship of animals, and the people do not believe in the interchange of souls between men and animals. There exists, however, some sort of superstition concerning one small bird called "dadir." It is caught when young, and small rings are fastened to its legs, after which it is set free, and no one is permitted to harm it in any way. They think that it is unlucky to hurt it; and should a man by accident break its leg, they expect one of his cows to get its leg broken. The feathers of another highly-valued red bird are used to try by ordeal persons accused of falsehood. It is considered to be a bad omen if a gazelle crosses a man's path; and if it should occur, the man usually turns back and gives up his project, whatever it may be. The lizard is known, and no one is allowed to kill it.

Various curious legends prevail with regard to animals. I will mention one as a specimen.

A monster lion is said to have shaken the earth by his roars. The shock was so great that all the people fell to the ground, and the lion proceeded to eat them. One man, however, entreated the Being, who had created both man and beast, to make the lion a little smaller, as he was too great and powerful for men; his request was granted, and the lion forthwith was reduced in size to his present dimensions.

Among numerous fables, the following may be given:—

On a certain occasion the animals all meet together to dance and enjoy themselves. Soon, however, they found that they were encircled by men, who set fire to the grass on all sides. The rabbit was most officious in proposing plans of escape. One of his suggestions was that the weasel (?) should make a hole in the ground, into which they might all flee for refuge. When the danger came quite near, he forgot every one else in his endeavours to save himself, but without avail, for they were all burnt up except the weasel (?), and a small bird who had been on the watch, and who, as soon as he saw the danger, warned his friends, and then flew away. The rabbit came to his end as follows:—The weasel (?) had taken his advice and dug a hole in the ground, into which he entered, but the rabbit bit off his tail and pulled him out, getting into the hole himself. In revenge, the weasel told the men where the rabbit was, and as they looked for him the weasel managed to make good his own escape.

Hunting.—The hunting season is a very important time in the Madi country, for it immediately follows a period of agricultural labour, and finds the people ready for the enjoyment of a holiday, and of a sport which they keenly appreciate. When the corn is all dried and stowed away in the granaries, the hunting begins, and continues for several months—that is, until the rain commences again. Very large hunting parties are formed, people from numerous villages assembling together, and being sometimes joined by parties from other friendly tribes.

The following is the way in which the notice of a hunt is given:—A man is sent round to all the villages, and as he passes by each hut he strikes with a peculiar stick one of the stones by the door of the hut. This signal is followed by a formal declaration that a hunt is arranged for a given day, and that all who wish to take part are to meet at a given place. When the time has arrived, and the hunters assembled, they divide into companies, and encircle a tract of country often several miles in extent. One company takes up its position on the side from which the wind blows, and sets fire to the long grass; as it is burnt down, the animals rush towards the other companies, who stand in long double rows, shooting their prey as they pass by. If a buffalo happens to be amongst the fugitives, he usually proves an awkward customer, as instead of running straight forward he will rush into the ranks of his foes, and cause no little commotion, often killing or wounding several of the huntsmen. When an animal is killed, it is the prize of the man who first shoots it, though its death is probably accomplished by others.

The right of possession does not appear to be decided by distinguishing arrow marks, but great care is taken to identify the shooter, and quarrels often arise about it, and are frequently only settled by a fight. It is virtually a case of much ado about nothing, for this right, which is so jealously guarded, concerns only the tail or the horns of the animal, which are kept as a trophy. Any one who has taken part in a hunt has a perfect right to his share in the booty, which is shared alike by all, each man getting an almost equal part of the spoil. Even should one party be more successful than another, the unlucky hunters get the same share as those who have been successful. Should an animal be first shot with a borrowed bow and arrow, the lender gets the trophy; but such transactions only take place between brothers or very intimate friends. Successful hunters are long kept in remembrance, and their exploits are handed down from father to son.

The Madis do not appear to have any special ceremonies or dances connected with their hunting expeditions, but in subsequent dances, those who have been distinguished in hunting, or women who have been very active in giving water to the men and won special renown, are celebrated in song. No great feast takes place after a hunt, but friends are sometimes invited in small parties to eat buffalo, &c.

Before going to the hunt the men paint their faces in stripes of different colours, and put iron rings on their necks, arms, and (sometimes) ankles, and the white tail of some animal round their necks. They carry their arrows in a goat-skin bag, hung over the shoulder or by a string which passes round the neck. In the left hand they hold the bow and two or three arrows; in the right hand they carry the spear. They start very early, so as to reach the hunting ground soon after sunrise, and they hunt all day. The women start later, carrying water on their heads in earthen jars, in the neck of which bunches of leaves are placed to keep the water cool. A small gourd floats on the top of the water to keep it from spilling, and serves as a drinking-horn.

These large hunting parties are only undertaken in the hunting season, but individuals hunt at other times. Young people and children hunt rabbits, gazelles, &c., not far from home. Women catch guineafowl by driving them about, as they soon get tired and cannot fly far. Sometimes large companies of boys undertake a hunt for the old women. On their return they all walk together in regular order to the huts where the old women live, laden with the spoil, and for this good work they are always invited to dinner. Should the old women have too much meat brought to them, they make presents to their friends.

All the wild uninhabited land surrounding a tribe belongs to the tribe as a whole, and may be hunted in by anyone. Individuals or parties may also hunt in the country which belongs to a neighbouring tribe, if that tribe is friendly. Should a man go alone to hunt in an enemy's country, he will not be interfered with, if he behaves well; but if he be insolent, the people will fight with him.

The chiefs do not often take part in the hunt; possibly the people do not like them to be needlessly exposed; and there is a tradition of a great chief having been killed in a hunting fray, and his body having been lost.

Gazelles are hunted as follows:—Some of the dogs run in front of the animal to distract its attention, whilst two or three creep quietly up from behind, and seize it. The dogs are kept by individuals, and not in large packs.

All large animals are cut up when killed, and not carried away whole. There is much waste, as what cannot be easily taken away is left. Small game is carried home on the head, or slung on a pole and carried by two men.

The Madis are very skilful with bow and arrow, and can hit birds on the wing. No tribute is paid in game. Water only is drunk while hunting. The meat is dried over a fire to preserve it.

The people are not influenced to migrate by the habits of the animals they hunt; good land is their great desire.

Traps.—The various modes employed for entrapping animals are of interest.

Hippopotami and rhinoceros are caught in pits. Deep holes are dug in the ground, into the bottom of which wooden stakes are driven with spikes projecting from the upper end, and then the holes are covered over with sticks and grass, strong enough to bear a man's weight, but unable to sustain large animals, which, falling in are often killed by the spikes, or at least badly wounded.

Buffaloes are caught by means of a skin rope attached to a pole which is stuck into the ground; at the end of the rope there is a noose, which is arranged round a small hole dug in the ground; the rest of the rope is hidden by twigs and leaves. The buffalo puts his foot into the hole, and in getting it out the noose is drawn tight, and the animal has to drag the heavy pole. He is thus easily tracked and speared.

To trap guineafowl, a string is made of hair from a cow's tail, a noose is placed among the small branches of a low plant in their run, into this they run their heads and are held fast.

Another trap is made of a long basket with a narrow opening at one end. It is placed on the ground in one of the narrow paths running through the high grass; small animals find their way into it, but cannot get out again, as the twigs of which the basket is made are so arranged inside that they fly back from the sides and prevent the animal retreating.

Birds are caught in the following ways:—

1. A noose is attached to a bent bough, and so arranged as to spring back and snare any bird that touches it.

2. One end of a flat stone is placed on the ground, and the other supported by a stick to which is tied a piece of string. The birds being attracted to food placed underneath the stone, pull the string, and the stone falls on them.

3. A number of sticks are driven into the ground, and nooses fastened to them; dhurra is then scattered about, and as the birds scratch the ground they get their legs caught.

String traps are arranged at the doors of the fowl huts to catch the wild cats when they try to steal the poultry.

At night boys are very fond of catching rats by firelight; they lie flat on the floor, very still, holding a round pan with dhurra in it, the rats come to eat, and as soon as near enough an inverted jar is quickly put over them.

Fishing.—The Madis adopt various methods of fishing.

Sometimes they dive into the water and while swimming underneath stick the fish with an iron hook; a line is fastened to this, the one end of which is wound round the fisher's hand, with which he also holds the wooden handle. The hook looses from the handle and remains in the fish, the man then swims to land and hauls it in.

Sometimes they fish at night by firelight, shooting the fish with iron-headed arrows. Nets are also used. They are drawn across a river and held at both ends. Men go up stream, and then swim down with a splashing stroke driving the fish to the net. In this way large numbers are caught, and a general distribution of the spoil takes place.

These are the methods employed in catching very large fish. A smaller kind of fish is caught by the women in shallow water. They use a poisonous fruit, about the size of a gooseberry. This fruit they grind into a coarse powder, and carry to the water in baskets. They then scatter it on the surface, and the fish eat it, and soon die. They are afterwards collected in baskets, and as the poison is not injurious to men, they are good for food. Children also fish by shooting with bow and arrow, and swimming after the fish they hit; many lives are lost through boys venturing into rapid rivers.

Sometimes in small rivers, instead of a net, a wickerwork barrier is constructed across the stream; another movable one is then introduced up stream, and gradually carried down until a short distance from the first barrier; the fish thus brought together are then caught by hand, and thrown on to the bank.

A fish trap is also made of wooden latticework, several feet across at one end and narrow at the other; this is placed beneath waterfalls or below rapids. Sometimes nets like our landing nets are held under waterfalls, to catch the fish as they come down. Wooden dams are also erected across rivers. Poles are fixed in the ground and cross beams fastened to them, holes being left of such a size that the fish in trying to get through stick fast and are collected each morning. These dams are left until the river gets swollen by the rains, and washes them away.

Fish are cured by being dried by the fire or in the sun, and keep good for considerable time.

Manufactures—Woodwork.—Numerous articles are manufactured from wood. Ladles, stools, handles for agricultural implements, bows, arrows, and walking-sticks. Nails are not used, bu the articles are either cut out of blocks of wood, or tied together with string, leather thongs, or iron wire. The instruments employed are—knife, axe, and a kind of plane. Fire is also used to hollow out wood and to harden it.

Smelting.—A hut or shed is set apart for carrying on smelting operations, several men working in the same hut. A number of fires are kept going, and the bellows are used as follows:—A large earthenware bowl with a hole at the side near the bottom is placed near the fire, and a clay pipe is constructed from this hole to the fire. The top of the bowl is covered with a soft skin, in the middle of which a hollow stick is fastened. This stick being moved up and down, and the top being closed by a finger when moving down, causes the draught. The anvils and hammers used are of iron, the hammer being flat in shape. They are thus a little in advance of the surrounding tribes, who only use stone. Some few stone anvils and hammers are, however, still in use in the Madi tribe. Very good knives, hoes, and bracelets are constructed, as well as arrow-heads.

The smelting furnaces are conical in form, and about 5 feet high, layers of iron ore and charcoal being placed alternately. Six pairs of bellows are often used, each man working two, one with each hand. There is not very much beer drinking during the smelting, but a good deal of singing, the men working in time to the song. Relays of men work at this tedious operation.

Basket Work.—The manufacture of baskets is carried on largely. Various shapes and sizes are constructed of open wickerwork; they are made by men much after our own manner.

Baskets of dhurra stalks are woven by women in the following way:—The pulp is removed, the stalks opened out flat and cut into the requisite lengths. The bottom of the basket is first made, and the sides worked up from it, being woven very close. Some kinds of baskets are so closely made that they will hold milk, and small ones are made to serve as cups on a journey, as they are lighter than earthenware, and less fragile than gourds. The shapes vary, being round, square, or otherwise, and of different colours, according to the kind of dhurra stalk used. Sometimes the various colours are blended. Women also make baskets of young doleb palm leaves. Pots are covered by a loose wickerwork for carrying. Spring baskets are made by men. They are chiefly used for ornamental purposes, and not of much practical use.

Pottery.—The manufacture of pottery is carried on by the women. A grey clay having been freed from stones is mixed with water to the consistency of dough; much care is taken that there should be no lumps in it, and that it should not be too wet or too dry. This dough is left in a hut for a day, being placed on and covered by leaves. The women then commence to make the jars, forming the bottom first on a wooden tray, working the sides up with their hands and moulding it into shape. No wheel is used. The vessels made vary very much in size and shape. Some are round and open like our basins, some have narrow necks widening out again at the top. When formed they are ornamented by lines made horizontally and at right angles below the top rim, which is often made to curve over. This marking is done with a sharp bit of stone such as is used for cupping, or with a sharp pointed stick. The jars are then painted black, or black with a red neck. They are left in a hut for a day or two to dry, then put in the sun for a day or two more, and lastly they are fired. Quite a trade is carried on by the makers of pottery, who keep a store of their goods for sale. Some very large sized jars are made for holding semsem; these are made by men, and in forming them a grass mould is used.

Painting.—The Madis decorate their bodies with paint for dances, washing it off again when the festivities are over. Red, blue, white, and black paints are used. The red is oxide of iron, the black is made from charcoal. The paint is applied with the finger in stripes about half an inch broad on the face, arms, shoulders, and chest. Women paint their faces, chest, and upper part of their arms, and some confine the paint to one part of the body only. The designs vary with taste. No application is made to the eyes. They do not stain their nails.

String.—String is made from the fibrous bark of five or six different trees. This substance is first dried in the sun for a day or two, then wetted, and buried for two or three weeks, at the end of which time it is taken out and heaped up under a tree. Here the men work, beating the fibrous pulp with a piece of wood on the smooth trunk of a tree which lies on the ground. They then work the fibres into string by rubbing them into a twist with their hands on their thighs.

To make cord, they fasten two pieces of string to their toes, and twist them together with their hands, repeating the process until the cord is of the required thickness and length. In making rope a cord is tied between two trees, and others wound round it in a spiral manner.

String is made of various other substances—of the hairs from the cow's tail, of animal skins cut into stripes and twisted (these are very strong, and are used for trapping buffaloes); also from the tendons of cattle and wild animals; this kind is made very fine, two men being needed to work it. It is used for bow strings. String is also made from doleb palm leaves. Fishing nets are made with fibre strings, which is tied into knots by the hand, forming diamond-shaped meshes like our own netting.

No dye is used in making string, but it is sometimes of a red colour, because made with red fibres. No wax is used in this manufacture, but the string is sometimes rubbed with grease. A lump of fat is taken in the hand, and the string drawn rapidly through it. This is also done to the bow strings and nets, but not to the large ropes. As a rule, men make the ropes, and nets, and bow strings; but women make fine twine, and small nets for holding gourds, and for forming bags on which to hang up fruit, &c., to dry in the sun, or from the rafters of the huts.

Money.—A regular system of exchange is carried on in arrows, beads, bead necklaces, teeth necklaces, brass rings for the neck and arm, and bundles of small pieces of iron in flat, round, or oval discs. All these different articles are given in exchange for cattle, corn, salt, arrows, &c.

The nearest approach to money, in one sense, is seen in the flat round pieces of iron, which are of different sizes from $\frac{1}{2}$ to 2 feet in diameter, and $\frac{2}{3}$ inch thick. They are much employed in exchange.

This is the form in which they are kept and used as money, but they are intended to be divided into two, heated and made into hoes. They are also fashioned into other implements, such as knives, arrow heads, &c., and into little bells to hang round the waist for ornament, or round wandering cows' necks.

Ready-made hoes are not often used in barter; iron as above mentioned is preferred, and is taken to a blacksmith to finish according to the owner's requirements.

Any tools may be obtained ready made from a smith, and may be used in barter when new.

Compensation for killing a woman or for any serious crime must be paid in cattle. No cowries are used as coin in this district. No drawing or writing is known, but certain marks are used to distinguish between arrows, pots, and the like.

Measures.—A year is made up of twelve months or divisions, but the number of days in each division is said to vary—I could not make out how or why.

A day is from sunrise to sunset. The year begins about the first month of harvest, when the grain is quite dry. Distance is reckoned by time.

If you ask the distance to a place not very far away, they will often point to the sky and say—" When the sun is at that spot you may be there."

No measure of weight, quantity, or length is used.

The number of cows given to a son, or the number of things lent or borrowed, is remembered by means of small lengths of grass, bundles of which are kept in a basket on the wall of the hut. Dried beans are sometimes used for the purpose.

The Madis count by tens; hundreds are known, but not thousands. Sticks are sometimes notched to remember numbers.

Astronomy.—The twilight in this district is very short. The Madis divide the day into three parts—morning from about 5.30 to 10 A.M.; mid-day 10 to 3 P.M.; and afternoon from 3 to 6.30 P.M. So that, roughly speaking, sunrise and sunset begin and end the day. The names for sunrise and sunset are kadro-ersa, kadro-lobo. There are names too for several of the stars (calu). The Pleiades, Minge Minge. The larger star by which they tell the time, Toru. The milky way, Guguree (road).

Their study of the stars does not seem to go further than giving names to some of them. The winds are called Bluku. East, Duwerie; West, Huwerie. Night, Endo; Morning, Demindo.

SHORT VOCABULARY OF MADI WORDS.

Antelope	Kulă.
Arm	Kallah.
Arrow	Etu.
Bedstead	Surah.
Beads	Biallah.
Bow	Keiuyah.
Boy	Uiskorah.
Brother	Undŭ.
Brook	Ranga.
Buffalo	Kobi.
Cat (wild)	Yow.
Child	Wistissi.
Chin	Sisi.
Cow	Isah.
Chief	Wisyerra.
Crocodile	Tamorah.
Dog	Wīhi.
Drum (large)	Dattei.
„ (small)	Kurai.
Ear	Mbilli.
Earth	Kang-u.
Elephant	Kidi.
Eye	Komang.
Father	Dadă.
Face	Komomah.
Fire	Wado.
Fish	Censa.
Fish-hook	Mongo.
Finger	Denjerida.
Flute	Traülei.
Foot	Mīndima.
Forest	Wevu.
Fowls	Yaru.
Giraffe	Kerri.
Girl	Uiyo.
Goat	Wanya.
Grass	Lomah.
Head	Do.
Harp	Taumu.
Hair	Iavu.
House	Loko.
Iron	Kor-hi.
King	Yerra.
Knife	Evu.
Lake	Ulu.
Leg	Ndi.
Lion	Ubiu.
Man	Kurah.
Moon	Niahoa.
Mother	Ma.
Mouth	Haw.
Mouse	Lusiē.
Mountain	Doku.
Morning	Demindo.
Night	Endo.
Nose	Kano.
Ox	Dangmo.
Pipe	Tuku-taba
Rain	Mirē.
River	Rodi.
Rope	Kordi.
Serpent	Wiri.
Sister	Emi.
Sun	Kadroa.
Star	Calu.
Sleep	Kemelli
Tongue	Ndenda
Water	Weni.
Woman	Mbara.
Bad	Emeddi.
Big	Kiedra.
Black	Korndu.
Blue	Muri.
Good	Emettakin
Green	Yowi.
Heavy	E-ebtu.
Little	Tissi.
No	Lah.
Red	Ei-hi.
White	Einyi.
Yes	Wah.
1	Korlo.
2	Irio.
3	Utah.
4	Suwor.
5	Mwi.
6	Dakka.
7	Demrio.
8	Dumta.
9	Dumsor.
10	Dumte.
11	Dumte Korlo.
12	„ Irio.
13	„ Utah.
14	„ Suwar.
15	„ Mwi.
16	„ Dakka.
17	„ Demrio.
20	Bute-Irio.
30	Bute-Otah.

I consider that these notes would be far from complete were I to omit some mention of the Madi language. I have, therefore, given above an extract from the vocabulary I collected The language is rich and melodious, and apparently lends itself well to oratory and song. It belongs to the Negro group of languages, for the Madis are pure negroes.

NOTE.—I had at first intended to illustrate this paper with drawings from objects in my collection, which are interesting as being the only ones that have yet found their way into Europe. Finding, however, that somewhat similar articles may be found depicted in *Geschichte der Waffen*, Band iii., Berlin und Leipzig, 1877, and in Schweinfurth's *Artes Africanæ*, Sampson Low, 1875, this has been deemed unnecessary.

4. On the *Crinoidea* of the North Atlantic between Gibraltar and the Faeroe Islands. By P. Herbert Carpenter, D.Sc. (Camb.), Assistant Master at Eton College. With some Notes on the *Myzostomida*, by Prof. L. von Graff, Ph.D. Communicated by Mr John Murray.

INTRODUCTION.

This communication falls conveniently into two sections—I. dealing with the specimens obtained by H.M.SS. "Lightning" and "Porcupine," during what may be called the pre-Challenger period of deep-sea exploration; II. concerning those dredged by the "Knight Errant" and "Triton" during the surveys of the Wyville Thomson ridge, which were conducted in the years 1880–82.

All the species will be properly described and illustrated in the "Challenger" Reports; but many reasons seem to render it desirable that some of them, and more especially the *Comatulæ*, should be briefly noticed before the larger report can be published.

My friend Professor L. von Graff has kindly sent me a short account of the *Myzostomida*, from which it will appear that four species of these parasites have been added to the two already known in the British seas.

I. *The Crinoids obtained by H.M.SS. "Lightning" and "Porcupine,"* 1868–70.

The detailed zoological results of the preliminary dredging expeditions of the "Lightning" and the "Porcupine," in the years 1868–70, have been so completely cast into the shade by the magnificent collections of the "Challenger," that little is known about many of the deep-sea animals obtained by these expeditions beyond the first references to them in the reports of Sir Wyville Thomson, Dr Carpenter, and Dr Gwyn Jeffreys, in the *Proceedings of the Royal Society.*

The Annelids, Corals, Echinids, and Mollusca soon found their way into able hands, and have been fully described in the publications of various learned societies. But as regards most of the other groups no detailed results have ever been published. This want of systematic information about our earlier expeditions is not to be wondered at, when it is remembered that the "Challenger" sailed but little more than two years after the return of the "Porcupine" from the Mediterranean, and that Sir Wyville Thomson, in whose hands the collections mostly remained, was in bad health, with his time much occupied by his professional duties and by the preparations for his four years' absence. When he returned the "Porcupine" collections were entirely dwarfed by those of the "Challenger;" and it is only now that they have been examined by Mr Murray that specimens dredged nearly fifteen years ago are coming into the hands of specialists, who are working them up together with the "Challenger" material, and with that of the "Knight Errant" (1880) and "Triton" (1882).

Nearly the same thing has taken place on the other side of the Atlantic, little being yet known about many of the types obtained by the U.S. ships "Corwin," "Bibb," and "Hassler" (1868, 1869, 1872); and they are now being described by those specialists, in whose hands have been placed the larger collections of the "Blake" (1877–80), second only in importance to those of the "Challenger."

Before sailing in the "Challenger," Sir Wyville Thomson read before the Society a paper* entitled "On the Crinoids of the 'Porcupine' Deep-Sea Dredging Expedition." It was, however, by no means complete, as regards either the list of species obtained or their geographical distribution; and in the following pages I propose to partially make good this deficiency. When our knowledge of the Crinoids fifteen years ago is taken into consideration, the material obtained by the "Porcupine" must be regarded as comparatively rich. For it includes four stalked Crinoids, three of which were new to European seas and also new to science, while one represents a new generic type altogether; and among the seven *Comatula* species were three or possibly four new forms, one representing a genus which, up till very lately, has scarcely been known to occur outside the limits of the tropics. Sir Wyville Thomson's list embraces only seven species of Crinoids altogether; whereas eleven different types were really obtained, seven being *Comatulæ*, and four stalked Crinoids, the latter including three additions to the four species then known.

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* *Proc. Roy. Soc. Edin.*, vol. vii. pp. 764–773. A large portion of this paper was also printed in *The Depths of the Sea*, pp. 434–454.

These facts seem to me of sufficient interest to merit being treated separately, so that they may not be lost sight of in the general account of the Crinoids which will appear in the "Challenger" Report.

Family PENTACRINIDÆ.

Genus *Pentacrinus*, Miller.

Cainocrinus, Forbes.
Picteticrinus, de Loriol.

1. *Pentacrinus wyville-thomsoni*, Jeffreys.

H.M.S. "Porcupine," 1870. Station 17. Lat. 39° 42′ N., long. 9° 43′ W. 1095 fathoms. Temp. 39°·7 F. Ooze. "About twenty specimens."

Remarks.—This fine species was worthily dedicated to Sir Wyville Thomson, in the Report of Drs Carpenter and Gwyn Jeffreys; but no further description of it was published until the appearance in 1872 of *The Depths of the Sea.* This contains a good figure, with a description by Sir Wyville, which is identical with that given in his paper on the "Porcupine" Crinoids. A series of five beautifully executed plates, illustrating the anatomical characters of the skeleton, which were drawn by Mr Hollick for Dr Carpenter, will appear in the "Challenger" Report.

P. wyville-thomsoni has a closed ring of basals, and would therefore belong to Forbes' genus *Cainocrinus,* which has recently been revived by de Loriol.* I have elsewhere given my reasons for regarding *Cainocrinus* as indistinguishable from *Pentacrinus.*†

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* *Monographie des Crinoïdes fossiles de la Suisse*, p. 111.

† *Journ. Linn. Soc. Zool.*, vol. xv. p. 210; and *Bull. Mus. Comp. Zool.*, vol. x. No. 4, p. 168.

Family Bourgueticrinidæ, de Loriol.

Genus *Rhizocrinus*, M. Sars, 1868.

Bourgueticrinus, Pourt., 1868.
Democrinus, Perrier, 1883.

2. *Rhizocrinus lofotensis*, M. Sars, 1868.

Bourgueticrinus hotessieri, Pourt. 1868.
Rhizocrinus lofotensis, Wyv. Thomson, 1872 (pars).

H.M.S. "Lightning," 1868. Station 12. Lat. 59° 36′ N., long. 7° 20′ W. 530 fathoms. Temp. 47°·3 F. Globigerina ooze. Three small specimens without arms.

Station 16. Lat. 61° 2′ N ; long. 12° 4′ W. 650 fathoms Globigerina ooze. Two small specimens without arms.

"Once or twice we found a fragment of the stem of *Rhizocrinus* in the cold area." *

Remarks.—So far as my information goes, this widely distributed species was never dredged by the "Porcupine," not even on the the "*Holtenia*-ground" in 1869. But according to Sir Wyville,† "several occurred attached to the beards of the *Holteniæ* off the Butt of the Lews." This would be at Stations 47 and 90, both of them close to No. xii. of the "Lightning" cruise, which was the original *Holtenia*-ground, and was described by Sir Wyville as being in the Faeroe channel. There is, however, no mention of *Rhizocrinus* in the accounts of the dredgings at these stations, either in *The Depths of the Sea*, or in the Royal Society Report; and I suspect therefore that Sir Wyville was speaking from memory only, and confounded the dredgings of the two years. At any rate, if the "Porcupine" did obtain specimens on the *Holtenia*-ground in 1869, they have since disappeared.

Sir Wyville mentioned individuals of considerable size as having been dredged by the "Porcupine" in 862 fathoms off Cape Clear. They really belong, however, to the species which three years later was met with off Barbadoes by the "Hassler," and was subsequently described by Mr Pourtalès under the following name:—

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* *The Depths of the Sea*, p. 124.

† *Ibid.*, p. 450.

3. *Rhizocrinus rawsoni*, Pourt., 1872.

Rhizocrinus lofotensis, Wyv. Thomson, 1872 (pars).
Rhizocrinus rawsoni, P. H. Carpenter, 1882.
Democrinus Parfaiti, Perrier, 1883.

H.M.S. "Porcupine," 1869. Station 42. Lat. 49° 12′ N., long. 12° 52′ W. 862 fathoms. Temp. 39°·7 F. Ooze with sand and shells. Two armless specimens.

Station 43. Lat. 50° 1′ N., long. 12° 26′ W. 1207 fathoms. Temp. 37°·7 F. Globigerina ooze. Two young specimens, one without arms.

Remarks.—These four specimens, as already indicated, were really the first discovered examples of *R. rawsoni;* but they differ from *R. lofotensis* far less than the Caribbean individuals do.* Those from Station 42 were noticed by Sir Wyville at the time they were obtained, and described as unusually large examples of *R. lofotensis.* But I am not aware that he ever made a closer examination of them. After reading Pourtalès' description of the Caribbean *R. rawsoni*, I came to the conclusion that the "Porcupine" specimens should really be referred to this type; and this view was confirmed when the originals of Pourtalès' description were sent to me last year (1882), as I have pointed out in my "Blake" report.

The two young individuals from Station 43 seem to have been altogether overlooked; for they are not mentioned either in the Royal Society's Report, *The Depths of the Sea*, or the paper on "Porcupine" Crinoids. They did not come into my hands until August last, having been discovered by Mr Murray among Sir Wyville's collections at the University. They are the youngest specimens of this type which I have seen. Each has 28 joints in the stem, from the calyx to the root; but its length, which is only 20 mm. in the smaller, is 24·5 mm. in the larger individual. The majority of the joints are cylindrical and elongated, only a very few at the base of the stem showing the characteristic dice-box shape with expanded ends. The length of the calyx is almost the same in both specimens, 1·8 mm.; though its diameter across the radials is greater in that which has the longer stem. It is mainly composed of the basals, which are 1·2 mm. in height, and form a nearly cylindrical tube, at the top of which are the short radials, having a more decided upward and outward slope. This causes the calyx to appear slightly constricted at the level of the basiradial suture, a feature which is very marked in some varieties of the adult form.

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* "The Stalked Crinoids of the Caribbean Sea," *Bull. Mus. Comp. Zool.*, vol. x. No. 4, pp. 174, 175.

As compared with equal sized specimens of *R. lofotensis*, these young individuals of *R. rawsoni* are distinguished by the relatively great height of the calyx in proportion to its width, the length of the basals, and the expansion of the calyx at the basiradial suture. The basals of *R. lofotensis* (uppermost stem-joint, Sars.) have a smaller share in the formation of the cup, and it expands uniformly upwards from the stem to the upper margin of the radials.

It is noteworthy that even these two young individuals from the same locality present differences in the shape of the calyx such as are more distinct in adult specimens from different localities in the East and West Atlantic. Perrier's genus *Democrinus* * is founded upon a variety of unusual size, with a great disproportion in the heights of basals and radials, and a somewhat strongly marked circular furrow at the level of the highest points of the basals, so that it crosses the middle of the radials.

Genus *Bathycrinus*, Wy. Th., 1872.

Ilycrinus, Danielssen & Koren, 1877.

4. *Bathycrinus gracilis*, Wy. Th., 1872.

H.M.S "Porcupine," 1869. Station 37. Lat. 47° 38′ N., long. 12° 8′ W. 2435 fathoms. Temp. 36°·5 F. Globigerina ooze.

One nearly complete specimen, and one stem with the basal ring attached, but wanting the rest of the calyx.

Remarks.—A figure of this species was given by Sir Wyville Thomson on page 453 of *The Depths of the Sea*, together with the same description which he published in his paper on the

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* Sur un nouveau Crinoïde fixé, le *Democrinus Parfaiti*, provenant des dragages du "Travailleur," *Comptes Rendus*, Tome xcvi. No. 7, pp. 450, 451. See also "Note on *Democrinus Parfaiti*," *Ann. & Mag. Nat. Hist.*, May 1883, p. 335. I am indebted to Professor Perrier's kindness for a drawing of this interesting type.

"Porcupine" Crinoids. This, however, is not quite accurate, for there is no mention of any calyx-plates below the radials, the lower portion of the head being said to consist "of a gradually expanding funnel-shaped piece, which seems to be composed of coalesced upper stem-joints." Subsequently, however, Sir Wyville found that in *B. aldrichianus*, from the Southern Sea, there is "a series of basals which are soldered together into a small ring, scarcely to be distinguished from the upper stem-joint."* The existence of basals in *Ilycrinus* (*Bathycrinus*) *carpenteri* was also recognised by Danielssen & Koren,† who were fortunately able to see the interbasal sutures in young individuals, though they entirely disappear in the adult; and there is a similar basal ring in *B. gracilis*, intervening between the radials and the numerous thin joints at the top of the stem.

The two outer radials and the two lowest brachials of *B. gracilis*, and also of *B. aldrichianus*, were described by Sir Wyville as respectively united by syzygy, while Danielssen and Koren made the same statement respecting *B. carpenteri*. In all these cases, however, the supposed syzygy is really a modification of the ordinary bifascial articulation permitting lateral movement only, which is so common in the *Comatulæ*, and is also characteristic of four species of *Pentacrinus;* for a third and smaller bundle of fibres is inserted into a deep pit at the lower or dorsal end of the vertical articular ridge on each joint-face. Externally, this form of articulation looks very much like a syzygy, as the joints are brought into closer connection than when they are united by a pair of muscular bundles. But a glance at their terminal faces is sufficient to show that the plainness of *Pentacrinus* or *Rhizocrinus*, or the striation of the *Comatula*-syzygies is altogether absent, and that they are marked by distinct ridges and fossæ.

According to Sir Wyville's description, there are none of these so-called "syzygies" in the arms of *B. gracilis* beyond that between the first two joints; while in *B. aldrichianus* there is a syzygy between the fourth and fifth brachials, and at irregular intervals beyond them; but the "alternate syzygies in the arms, which form so remarkable a character in *Rhizocrinus*, are absent." I find, however, that in both species the grouping of the arm-joints is exactly the same as was observed in *B. carpenteri* by Danielssen and Koren, if the term "trifascial articulation" be substituted for "syzygy" in their descriptions. In the nine lowest brachials there are alternations of a pair of joints united trifascially, and a single joint with muscular attachments at each end; while beyond the ninth brachial the two forms of articulation alternate with great regularity. The presence of this trifascial articulation, and its peculiar distribution may therefore be considered as characteristic of *Bathycrinus;* and the "alternate syzygies" in the arms, which are supposed to be absent in this genus, are really present in a modified form. Neither do the arms "resemble in character the pinnules of *Rhizocrinus*," or "show no trace of pinnules" in *B. gracilis*. For one or two of them have little stumps on their terminal joints, which give them the appearance of bifurcation, just as at the growing points of the arms of young *Comatulidæ* and *Pentacrinidæ;* and I see no reason to doubt that these stumps are the commencing pinnules.

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* "Notice of new living Crinoids belonging to the Apiocrinidæ," *Journ. Linn. Soc. Zool.*, vol. xiii. p. 50.

† *Nyt. Mag. for Naturvidskaberne*, Bind. 23, p. 4.

Family COMATULIDÆ.

Genus *Antedon*, Frém.

5. *Antedon rosacea*, Linck. sp.

"Frequent in water of moderate depth." [*] One individual which seems to belong to this species, though certainly representing a rather strongly marked variety, was obtained somewhere in the North Atlantic, but the exact record of its locality has unfortunately been lost.

Among the numbers of *Ant. phalangium* of various ages which were dredged in 1870, at 30 to 120 fathoms, on the Skerki Bank, and at 50 to 120 fathoms, in the Bay of Benzert, on the Tunis coast, were five young specimens certainly not belonging to this type, and probably, therefore, to be referred to the Mediterranean variety of *Ant. rosacea*. It is impossible to state now the exact depth from which they were collected, but it was probably not below 50 fathoms, as *Ant. rosacea* has not yet been found in the

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[*] *Proc. Roy. Soc. Edin.*, vol. vii. p. 765.

Mediterranean at a greater depth than 37 fathoms. I am still in doubt whether some of the very varied forms usually referred to this type should not be distinguished by the name *Ant. milleri*, as was done by Müller, and more especially by Sir Wyville Thomson. But I would postpone giving a decided opinion until I have been able to add considerably to my already large series of specimens from widely-separated localities.

6. *Antedon phalangium*, Müll. sp.

Comatula woodwardii, Barrett.
Comatula celtica, Barrett.
Antedon celticus, Wyv. Th. &c.
Non *Antedon celtica* of von Marenzeller, and Sladen.

H.M.S. "Lightning," 1868. Station 13. Lat. 59° 5′ N., long. 7° 29′ W. 189 fathoms. Warm area.

H.M.S. "Porcupine," 1869. The Minch, 60 to 80 fathoms. Several specimens. Off Loch Scavaig, Skye.

1870. Station 13. Lat. 40° 16′ N., long. 9° 37′ W. 220 fathoms. Temp. 52° F. Several specimens.

Off Cape Sagres, 45 fathoms. Several specimens.

Off Carthagena, 80 fathoms. Several specimens.

Bay of Benzert, 50 to 100 fathoms. Abundant.

Skerki Bank, 30 to 120 fathoms. Abundant.

Remarks.—It has been noted elsewhere * that Barrett's *Ant. celtica* from Skye is really identical with the *Ant. phalangium* of Müller, which was considered until lately as one of the rarities of the Mediterranean, for it inhabits somewhat deeper water than *Ant. rosacea.* Sir Wyville Thomson noted it as occurring "in local patches to 150 fathoms off the north coast of Scotland;" but I have no record of it besides Stat. xiii. of the "Lightning" expedition, and neither the "Knight Errant" nor the "Triton" ever met with it.

The occurrence of this species off the Spanish and Portuguese coasts is of some interest; for it had not previously been recorded between the Mediterranean and the Minch. Curiously enough, it seems (until this year) never to have been obtained in any of the numerous dredgings, both public and private, off the French and British coasts between the parallels of 40° and 57°. One would certainly have expected its appearance during the first cruise of the "Porcupine" in the neighbourhood of the 100-fathom line on the west of Ireland; but no traces of it were met with. It was very abundant off the Tunis coast, both on the Skerki Bank and in the Bay of Benzert, specimens of all ages coming up on the tangles in great numbers, though unfortunately in a very much mutilated condition. These were noticed by Sir Wyville Thomson in the following passage: *—"Many examples of the form known to Continental naturalists under the name of *A. mediterraneus*, Lam. sp., were dredged in the Mediterranean off the coast of Africa. I do not feel satisfied that this is identical with *Antedon rosaceus* of the coast of Britain, though the two specific names are usually regarded as synonyms. There is a great difference between them in habit, a difference which it is difficult to define." It is curious that the extreme length of the dorsal cirri of these individuals did not lead Sir Wyville to identify them with *Ant. phalangium* (*celtica*, Barrett), of which this is one of the special marks, as he himself points out. But I am strongly inclined to believe that he is right in differentiating the common Mediterranean type from the British *Ant. rosacea.* As pointed out above, however, the "Porcupine" only got a very few young specimens of it on the African coast.

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* "Note on the European *Comatulæ*," *Zool. Anzeiger*, Jahrg. iv. p. 520.

It is singular that while no parasitic *Myzostoma* occurred among the numbers of *Ant. phalangium* dredged on the Tunis coast, some of the individuals obtained in the Minch in 1869, and at Station 13 in 1870 (off Mondego) proved to be the hosts of a new species, *M. alatum*, which is briefly described by Professor von Graff further on. A single example of another new species, *M. pulvinar*, was also found attached to the peristome of one of the Minch specimens of *Ant. phalangium*, which does not appear to serve as host to the same species of *Myzostoma* as occur on *Ant. rosacea.*

7. *Antedon dentata*, Say, sp.

Antedon Sarsii, auct.

H.M.S. "Porcupine," 1869. Station 51. Lat. 60° 6′ N. long., 8° 14′ W. 440 fathoms. Temp. 42° F. One specimen.

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* *Proc. Roy. Soc. Edin.*, vol. vii. p. 765.

Station 54. Lat. 59° 56′ N., long. 6° 27′ W. 363 fathoms. Temp. 31°·4 F. One specimen.

Station 55. Lat. 60° 4′ N., long. 6° 19′ W. 605 fathoms. Temp. 29°·8 F. Two specimens.

Station 74. Lat. 60° 39′ N., long. 3° 9′ W. 203 fathoms. Temp. 47°·6 F. Three specimens.

1870. Station 17*a*. Lat. 39° 39′ N., long. 9°39′ W. 740 fathoms. Temp. 49°·3 F. One specimen.

Remarks.—This species occurs in profusion at moderate depths off the New England coast, over 10,000 individuals having been obtained by the "Fish Hawk" at a single haul. It is also abundant at moderate depths off New Jersey, near the locality (Great Egg Harbour, N.J.) whence Say's original specimens were obtained; and it agrees so well with his description of *Ant. dentata*, that the identity of the two can hardly be doubted.* The adoption of his specific name thus becomes inevitable, however undesirable this may seem to European naturalists, who have been so long accustomed to associate the type with the name of a deservedly honoured Norwegian zoologist.

Sir Wyville Thomson gave no definite list of stations for this species, though he mentioned the occurrence of more or less complete specimens or fragments in nearly every one of the deep hauls of the dredge from the Faeroe Islands to Gibraltar. So far as I am aware, its southernmost limit in the East Atlantic, and also its lowest bathymetrical range are at present united in Station 17*a* of the "Porcupine," 1870; 740 fathoms. It was obtained at 605 fathoms in the "cold area" in the previous year; but the U.S. Fish Commission have not dredged it below 238 fathoms off the New England coast.

Sir Wyville Thomson stated that one or two small examples of the pentacrinoid were procured in the Faeroe channel. Only one, however, has come into my hands. It is a trifle more advanced than that represented by Sars in figs. 9 and 11 on Tab. V. of his classical *Mémoires*. The arms are longer, with the first pinnule on about the twelfth joint. There is, however, but one cirrus, which seems to be the only one as yet developed, though it is of considerable size, reaching up to the level of the radial axillaries.

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* See Verrill, *Am. Journ. Sci.*, vol. xxiii. p. 222.

The stem is attached by a slight calcareous expansion at about its 35th joint to one of the rays of a *Rhabdammina abyssorum;* and it then passes on to form two other spreading attachments, with radicular branches sprouting from them on what appears to be a portion of a tubular hydroid.

8. *Antedon eschrichti*, Müll. sp.

H.M.S. "Porcupine," 1869. Station 57. Lat. 60° 14′ N., long. 6° 17′ W. 632 fathoms. Temp. 30°·5 F.

Sir Wyville Thomson stated that considerable numbers of this species were obtained in many of the cold area hauls; and he noted their small size as compared with more northern specimens. No. 57, however, is the only station of which any record has been preserved; and it is interesting as being by far the greatest depth at which this species has yet been met with. Its usual parasite *Myzostoma gigas*, Lütken, MS., was also obtained at this station.

Two pentacrinoids besides that of *Ant. dentata* were dredged in the cold area; but I do not think that either of them can be the one referred to by Sir Wyville Thomson in the following passage:—"A single example of a pentacrinoid in an early stage was found associated with *Ant. eschrichtii.* It resembled closely the larva of *Ant. sarsii* but the specimen was not sufficiently perfect for a critical examination." Neither of the larvæ which I am about to describe is at all like that of *Ant. dentata*, and I fear, therefore, that the one mentioned by Sir Wyville Thomson has somehow been mislaid.

No. 1. In this larva there is no trace of cirri, the anal plate separates two of the radials, and the arms are just beginning to sprout from the radial axillaries. There are five discoidal joints at the top of the broken stem, which is much more robust than that of the corresponding stage of *Ant. rosacea;* while the head, which exceeds 1 mm. in length, is nearly twice as big as that of the *rosacea* larva. The orals which rest directly on the radials recall those of *Hyocrinus*, having a deep median groove, only more marked than in that type, with the lateral edges folded over somewhat strongly. This interesting larva may perhaps belong to *Ant. phalangium*, but I rather doubt such being the case. For that species is almost the nearest ally of *Ant. rosacea;* and from what I have seen of the condition of the youngest unattached individuals, I should judge that the larva was not very different from that of *Ant. rosacea.*

I think it much more probable, judging from the robust nature of this larva, that it belongs either to one of the Arctic species, *Ant. eschrichti*, or *Ant. quadrata*, sp. n., or to *Ant. hystrix*, sp. n., which is as yet only known from the cold area. It is very likely only a younger stage of the larva next to be described.

No. 2. The stem, which is broken some 20 mm. from the calyx, forms an attachment to a hydroid tube at about its 30th joint, and is continued downwards half a dozen joints further. There are five discoidal joints below the rudimentary centrodorsal, which bears the sockets of five short cirri. Only one of them remains, however, reaching up to the top of the basals, which make up about half the height of the cup. The second radials and axillaries are well developed, as are also the arms, which are unfortunately broken at about the tenth joint. But even under these circumstances the head has a length of 4 mm. A slightly bifid plate, having a somewhat worn appearance, stands up in one of the interradii of the disc. It may be one of the orals, or as I am more inclined to think, the anal plate; for I cannot make out anything corresponding to it in the other interradii, which are, however, but imperfectly visible. A striking feature of this very robust larva, and one in which it resembles *Ant. dentata* rather than *Ant. rosacea*, is the large development of the arms before the appearance of the cirri. The radials and brachials are much larger than those of a recently detached individual of *Ant. rosacea.* This is also the case in a "Challenger" pentacrinoid from Ascension, which has a robust appearance like the one under consideration. The latter must certainly belong to one of the three *Antedon* species already mentioned as occurring in the cold area, though further identification is impossible.

9. *Antedon hystrix*, P. H. Carpenter, 1883.

Formula,[*] $A . 10 . \frac{c}{bc}$ ·

Centrodorsal hemispherical, and thickly covered with numerous long-jointed cirri, which vary considerably in appearance. One of the largest reaches 36 mm., and consists of forty smooth joints, of which all but the basal and terminal ones are longer than broad, the fifth to the tenth being especially so. The cirri attached round the upper edge of the centrodorsal are all of this smooth type, and may be observed in every stage of growth. But those attached nearer the dorsal pole are somewhat different in appearance. They are more slender, and their component joints are relatively shorter than in the other type; while the joints have slightly expanded distal ends, so as to overlap their successors. This is especially marked on the dorsal side, which is produced into a sharp forward projecting spine. I have reason to believe that these characters gradually disappear as the joints increase in age, and that the mature cirri of the two types are not very different in appearance, especially about what might be called the equator of the centrodorsal. But the smooth young cirri all round its edge are totally different from the spiny ones nearer the dorsal pole.

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[*] For an explanation of the signs used in these formulæ, see F. J. Bell, *Proc. Zool. Soc.*, 1882, pp. 530–535; and P. H. Carpenter, *ibid.*, pp. 731–747.

Traces of the first radials may be seen at the angles of the calyx; but there is no constancy about their appearance even in individual specimens. The second radials are short, even at the sides, and are often not visible at all in the middle line of the ray, owing to their being very deeply incised to receive the strong backward projections of the axillaries. These are quadrate in form, with their sides curved, especially the anterior pair; and they are distinctly longer than wide, sometimes almost seeming to overlap the centrodorsal; but much less than half the length is in front of the line joining their lateral angles. The first brachials have long outer sides and very short inner ones, but (like the second radials) are almost invisible in the middle line of the arm, owing to the very strong backward projections of the irregularly triangular second brachials, which nearly reach the axillaries. Both on these joints and on the rudely oblong third brachials, which are much wider than long, the pinnule-socket is placed much nearer the dorsal surface than usual. The next following joints are short and quadrate, with curved proximal and distal edges; and the pinnule is on the shorter side, the longer being marked by a backward projection.

There are syzygies in the 3rd and 8th brachials, and then at intervals of three or four joints throughout the rest of the arm. The lower brachials are triangular and slightly wider than long; but they slowly become quadrate and finally slightly elongated towards the arm-ends.

The first pair of pinnules (on 2 and 3 br.) are much longer and stouter than the next pair. They reach nearly 15 mm., and consist of some thirty smooth joints, the first six of which are short and nearly square. The second pair have but eighteen or twenty slender joints, and are only about 6 mm. long. The following pinnules increase gradually, both in length and stoutness, reaching 15 mm. in the outer parts of the arms. The two basal joints become slightly flattened and the succeeding ones elongated. They have a somewhat glassy aspect, especially in the later pinnules, while their ends present the usual dead white appearance. The same difference presents itself in the joints of the younger and more spiny cirri round the dorsal pole, and also in the pinnules and cirri of *Ant. dentata.* It recalls the contrast between the hyaline and porcellanous types of Foraminifera, though due to entirely different causes. The ovaries are long and fusiform, extending over the greater part of the length of the lower pinnules; and the disc is naked, or rather closely covered with irregular polygonal plates.

Diameter of centrodorsal 5 mm.; spread about 170 mm.

H.M.S. "Porcupine," 1869. Cold area? Two specimens, bearing seven individuals of *Myzostoma cirriferum*, F. S. Leuckart.

Remarks.—The foregoing description is based upon the characters presented by three examples of the type, two obtained by the "Porcupine" and one by the "Triton." They all agree very closely in their general features, and especially in the curious dimorphism of the cirri, which recalls that already noticed in *Eudiocrinus varians.** The shape of the axillaries and of the second brachials is very striking, the great length of the former being much more marked than in *Ant. eschrichti.* It is the characters of the radials and three lowest brachials which principally distinguish *Ant. hystrix* from *Ant. prolixa*, Sladen.† Both species are remarkable for the small size of the second, as compared with the first pair of pinnules; and this peculiarity distinguishes them from *Ant. phalangium.*

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* *Journ. Linn. Soc. Zool.*, vol. xvi. pp. 496, 497.

† Duncan and Sladen, *A Memoir on the Echinodermata of the Arctic Sea to the West of Greenland*, p. 77, pl. vi. figs. 7–10.

None of the cirri of *Ant. hystrix* reach the size of those borne by the smaller examples of *Ant. prolixa.* Many of these have a short dorsal spine on the distal edge which projects forwards over the base of the next joint, just as in the more centrally placed cirri of *Ant. hystrix.*

Ant. eschrichti is described in the "Porcupine" reports as abundant in the cold area. The only record which I have of its occurrence, however, is Station 57 (1869), 632 fathoms. But whether *Ant. hystrix* occurred here or not, we may assume with tolerable certainty that it is a "cold area" species; for the "Triton" specimen was obtained at a station where the temperature was below 0° C.

10. *Antedon lusitanica*, P. H. Carpenter, 1883.

$$\text{Formula, A.10.(2).}\frac{a}{c}.$$

Centrodorsal hemispherical, roughened at the dorsal pole, and bearing about a dozen slender cirri which reach nearly 30 mm. in length. They have about fifty joints, of which the first three or four are quite short, the next three much longer, and the following ones longer than wide, but gradually diminishing up to the fifteenth or twentieth joint. From this point (or earlier) to the end of the cirrus the joints have a well-marked dorsal spine, which is slightly less distinct in those just preceding the terminal claw. Ten arms, or (rarely) two distichals not united by syzygy. First radials scarcely visible except sometimes at the angles of the calyx. The second short and trapezoidal, with a strong median ridge, which is continued on to the axillaries. These are just pentagonal with slight backward projections into the second radials, and their sides are much flattened. This is still more marked on the outer sides of the first brachials, which are longer than their inner sides. The second brachials project more or less backwards into the first, and the third is a syzygial joint, the next three squarish, and the following ones more elongated with very oblique ends. The second brachials bear moderately long pinnules of about fifteen broad joints. The lowest have very prominent dorsal keels which are continued, though less marked, on to the later joints. The next following pinnules are altogether smaller, consisting of but a few slender joints.

Disc 5 mm. in diameter, thickly covered with numerous small plates, those at the sides of the ambulacra being rather more regularly arranged than the rest.

Colour, in spirit, brownish-white or greenish-white.

H.M.S. "Porcupine," 1870. Station 17*a*. Lat. 39° 39′ N., long. 9° 39′ W. 740 fathoms. Temp. 49°·3 F.

Ten mutilated specimens.

Remarks.—Nearly all the individuals obtained had the arms broken at the syzygy in the third joint beyond the radial axillaries; and it is therefore quite possible that the epizygal of this joint might sometimes have been a distichal axillary. In one example, at any rate, there are two distichal series, each consisting of two joints, the second of which is axillary. This species, therefore, seems to be dimorphic like *Actinometra pulchella*, and to constitute another exception to the general rule that ten-armed types are sharply distinguished from those in which the primary arms divide. The length and spiny character of its cirri, and the peculiarities of its pinnules, readily distinguish it from all the species of *Antedon* hitherto described. But it has many points of resemblance to some of those dredged by the "Blake" in the Caribbean Sea. It is a type of some interest for two reasons: it is the only European *Comatula* which is in the condition of the so called recent Cystid, *Hyponome sarsii*, *i.e.*, with a plated disc and the ambulacra converted into tunnels by the folding down of the plates at their sides; and it is the only European *Antedon* with more than ten arms.

11. *Actinometra pulchella*, Pourtalès, sp.

Antedon pulchella, Pourtalès, 1878.
Actinometra pulchella, P. H. Carpenter, 1881.

H.M.S. "Porcupine," 1870. Station 31. Lat. 35° 56′ N., long. 7° 6′ W. 477 fathoms. Temp. 50°·5 F. Clay.

One mutilated specimen.

Remarks.—I cannot distinguish this form from the smoother variety of that singularly protean species, *Act. pulchella*, of the

Caribbean Sea. It was dredged by the "Blake" at a very large number of stations; but the depth was nowhere over 300 fathoms, and rarely exceeded 200 fathoms; so that its discovery in the "Porcupine" collection increases both its bathymetrical and its geographical range. Except the two species of *Rhizocrinus*, it is the only Crinoid common to the European and Caribbean seas; while it is the only European species of *Actinometra*. This is an essentially tropical genus, a few species only ranging to the parallels of 35°, such as those at the Cape of Good Hope, Yeddo, and this Gibraltar specimen. The depth too, 477 fathoms, is much greater than that at which the genus usually occurs; so that this "Porcupine" specimen which, like *Rhizocrinus rawsoni*, was obtained in European seas long before its discovery on the other side of the Atlantic, is of interest in every way.

The "Porcupine's" discovery of *Actinometra pulchella* in the East Atlantic has been recently confirmed and extended by the dredgings of the telegraph-ship "Dacia," a few dismembered individuals having been obtained in lat. 34° 57′ N., long. 11° 57′ W., at a depth of 533 fathoms.

All the primary arms divide except one; but the number 20 is kept up by the fact that a palmar axillary is present on one of the secondary arms, a point which I do not remember to have met with in any of the "Blake" specimens. This involves a slight addition to the second of the two formulæ which I have given for this dimorphic type,* so that they become

$$\mathrm{a}\,.\,10\,.\,\frac{a}{b}\;;\ \text{and}\ \mathrm{a}\,.\,2\,.\,(2)\,.\,\frac{\mathrm{b}}{2}\,,\ \frac{a}{b}\,.$$

In the following list of stations at which Crinoids were dredged by the "Lightning" and "Porcupine," the forms which are now noticed for the first time are distinguished by an *.

Station List of Crinoids and Myzostomida, 1868–70.

H.M.S. "Lightning." 1868.

Station 12. Lat. 59° 36′ N., long. 7° 20′ W. 530 fathoms. Temp. 47°·3 F. Globigerina ooze.

Rhizocrinus lofotensis.

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* *Proc. Zool. Soc.*, 1882, p. 745.

Station 13. Lat. 59° 5′ N., long. 7° 27′ W. 189 fathoms. Temp. 49°·3 F.

Antedon phalangium.

Station 16. Lat. 61° 2′ N., long. 12° 4′ W. 650 fathoms. Globigerina ooze.

Rhizocrinus lofotensis.

H.M.S. "Porcupine." 1869.

Station 37. Lat. 47° 38′ N., long. 12° 8′ W. 2435 fathoms. Temp. 36°·5 F. Globigerina ooze.

Bathycrinus gracilis.

Station 42. Lat. 49° 12′ N., long. 12° 52′ W. 862 fathoms. Temp. 39°·7′ F. Ooze, with sand and shells.

* *Rhizocrinus rawsoni.*

Station 43. Lat. 50° 1′ N., long. 12° 26′ W. 1207 fathoms. Temp. 37°·7 F. Globigerina ooze.

* *Rhizocrinus rawsoni.*

The Minch, 60 to 80 fathoms; and off Loch Scavaig, Skye.

Antedon phalangium.
Myzostoma alatum.
M. pulvinar.

Station 51. Lat. 60° 6′ N., long. 8° 14′ W. 440 fathoms. Temp. 42° F.

Antedon dentata.

Station 54. Lat. 59° 56′ N., long. 6° 27′ W. 363 fathoms. Temp. 31°·4 F.

Antedon dentata.

Station 55. Lat. 60° 4′ N., long. 6° 19′ W. 605 fathoms. Temp. 29°·8 F.

Antedon dentata.

Station 57. Lat. 60° 14′ N., long. 6° 17′ W. 632 fathoms. 30°·5 F.

Antedon eschrichti.
Myzostoma gigas.

Station 74. Lat. 60° 39′ N., long. 3° 9′ W. 203 fathoms. Temp. 47°·6 F.

Antedon dentata.

Stations unknown.

Antedon rosacea, var.
{ *Antedon hystrix*.
{ *Myzostoma cirriferum*.

H.M.S. "Porcupine." 1870.

Station 13. Lat. 40° 16′ N., long. 9° 37′ W. 220 fathoms. Temp. 52° F.

* { *Antedon phalangium*.
{ *Myzostoma alatum*.

Station 17. Lat. 39° 42′ N., long. 9° 43′ W. 1095 fathoms. Temp. 39°·7 F. Ooze.

Pentacrinus wyville-thomsoni.

Station 17*a*. Lat. 39° 39′ N., long. 9° 39′ W. 740 fathoms. Temp. 49°·3 F.

Antedon dentata.
**Antedon lusitanica*.

Station 31. Lat. 35° 56′ N., long. 7° 6′ W. 477 fathoms. Temp. 50°·5 F. Clay.

**Actinometra pulchella*.

Off Cape Sagres. 45 fathoms.

**Antedon phalangium*.

Off Carthagena. 80 fathoms.

**Antedon phalangium*.

Bay of Benzert. 50 to 100 fathoms.

Antedon phalangium.
**Antedon rosacea* (young).

Skerki Bank. 30 to 120 fathoms.

Antedon phalangium.
**Antedon rosacea* (young).

II. *The Crinoids obtained by H.M.SS. "Knight Errant" and "Triton,"* 1880–82.

1. *Rhizocrinus lofotensis*, M. Sars.

H.M.S. "Knight Errant," 1880. Station 5. Lat. 59° 26′ N., long. 7° 19′ W. 515 fathoms. Temp. 45·4° F. Mud. Two young specimens without arms.

Station 6. Lat. 59° 37′ N., long. 7° 19′ W. 530 fathoms. Temp. 46°·5 F. Grey mud. A fragment only.

2. *Antedon rosacea*, Linck, sp.

H.M.S. "Knight Errant," 1880. In 53 fathoms on the plateau N.N.W. of North Rona. Lat. 59° 12′ N., long. 5° 57′ W. Rough ground.

One mutilated individual was obtained here. It closely resembles the "Porcupine" variety from an unknown locality, both of them having the first brachials shorter than usual and a better developed backward projection of the second brachials. The "Porcupine" specimen, which is the better preserved, has a somewhat more robust appearance than is generally presented by this species, and looks altogether as if its habitat were in the cold area.

3. *Antedon petasus*, Dub. and Kor., sp.

A single but tolerably perfect example of this well-known Scandinavian type was obtained by the "Triton" at a depth of 87 fathoms on the Faeroe Banks (Dredging Station No. 3. Lat. 60° 39′ 30″ W., long. 9° 6′ W. Sand and shells. Temp. 49° F.). It was officiating as host to no less than eighteen individuals of *Myzostoma cirriferum*, F. S. Leuckart.

4. *Antedon dentata*, Say, sp.

H.M.S. "Triton," 1882. Station 2. Lat. 59° 37′ 30″ N., long. 6° 49′ W. 530 fathoms. Temp. 46°·2 F. Mud. Five mutilated specimens, the disc varying in diameter from 2·5 to 4 mm.

Station 5. Lat. 60° 11′ 45″ N., and 60° 20′ 15″ N., long. 8° 15′ W. and 8° 8′ W. 433–285 fathoms. Hard ground; stones. Temp. 43°·5 to 40°·8 F.

The calices and arm-bases of two individuals were obtained here. The larger one, with a disc 6·5 mm. in diameter, does not reach the size of some of the specimens dredged by the "Blake" off the coast of New England.

Attached to the disc of each was an example of von Graff's new species *Myzostoma carpenteri*. That on the smaller individual was the larger of the two (2·3 mm.), almost rivalling its host in diameter.

Even the smallest of these seven individuals has fully developed ovaries; but it is only in the largest that the cirri exceed 10 mm. in length, and are composed of more than twenty joints.

This species was taken by the "Porcupine" both in the warm and in the cold areas.

5. *Antedon eschrichti*, Müll. sp.

H.M.S. "Triton," 1882. Station 4. Lat. 60° 22′ 40″ N. and 60° 31′ 15″ N., long. 8° 21′ W. and 8° 14′ W. 327 to 430 fathoms. Temp. 31°·5 to 30° F. Stones; mud.

A small but singularly interesting example of this well-known Arctic type. The cirri are small and comparatively delicate, not exceeding 20 mm. in length; and the arm-bases are but slightly tubercular. All the arms have been broken either at the second (8th) or third syzygy (12th or 13th brachial).

One can therefore study the appearance presented by the new arm-joints in various stages of growth. The lowest and therefore oldest of these new joints are most like those of the corresponding part of the arm in the adult, *i.e.*, triangular or very slightly quadrate, but relatively long in proportion to their width. These characters, however, do not disappear as they do in the adult, where the joints gradually become shorter and shorter, with a markedly triangular outline. But throughout the remainder of the restored arms the joints are quadrate and relatively long; while the two lowest pinnule-joints show but few traces of the flattening and peculiarities of outline which are so characteristic of the adult. It is just in these characters (besides the smaller size of the third pair of pinnules) that *Antedon quadrata* (No. 7) differs from *Ant. eschrichti;* and it is therefore to be regarded as a permanently immature form of the latter species.

6. *Antedon hystrix*, sp. n.

H.M.S. "Triton," 1882. Station 4. Lat. 60° 22′ 40″ N. and 60° 31′ 15″ N., long. 8° 21′ W. and 8° 14′ W. 327 to 430 fathoms. Temp. 31°·5 to 30° F. Stones; mud.

The single individual obtained here has been already described together with those previously dredged by the "Porcupine" (*ante*, p. 365).

7. *Antedon quadrata*, P. H. Carpenter, 1883.

Formula, $A . 10 . \frac{c}{b}$.

1877. *Antedon celticus*, von Marenzeller, *Wiener Denkschr.*, Bd. xxxv. p. 24 (separate copy).

1881. *Antedon celtica*, Sladen, *Mem. Arct. Echinod.*, p. 75.

1881. *Antedon celtica*, P. H. Carpenter, *Zool. Anzeig.*, Jahrg. iv. p. 520.

Non *Antedon celticus* of Barrett, Norman, Wyv. Thomson, &c.

Special Marks.—The lower arm-joints (after the twelfth) as long or slightly longer than wide and slightly quadrate in outline, though sometimes triangular. Those in the middle of the arm are distinctly quadrate, the length bearing a large proportion to the breadth; and the later ones are somewhat elongated. But none of the joints are shaped like an isosceles triangle, and much shorter than wide.

The third pair of pinnules (on 6 and 7 br.) are little more than half as long as the second pair; and the basal joints of the lower pinnules have their dorsal edges more or less produced into sharp flattened processes.

H.M.S. "Triton," 1882. Station 4. Lat. 60° 22′ 40″ N. and 60° 31′ 15″ N., long. 8° 21′ W. and 8° 14′ W. 327 to 430 fathoms. Stones; mud. Temp. 31°·5 to 30°. One good specimen.

Station 6. Lat. 60° 9′ N., long. 7° 16′ 30″ W. 466 fathoms. Stones. Temp. 29°·5 F. Two mutilated individuals and one fragment.

Remarks.—This species has caused me no little trouble. The first example of it known to science was dredged in 1872 by the ill-fated "Tegetthof" 5° west of Nova Zembla. It was minutely described by von Marenzeller * five years afterwards and referred to

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* "Die Coelenteraten, Echinodermen, und Würmer der k. k. österreichisch-ungarischen Nordpol-expedition," *Denksch. d. Wien. Akad.*, Bd. xxxv. p. 25 (of separate copy).

Antedon celticus, Barrett sp., of which only a very poor description had ever been published. In the meantime I had met with a specimen off Disco, when in the "Valorous" with Dr Gwyn Jeffreys (1875), and I recognised it at once as distinct from an *Ant. eschrichti* obtained during the same cruise. Three other examples were dredged by Fielden in the "Alert" a few months later, two at Discovery Bay (lat. 81° 41′ N.), and one at Franklin Pierce Bay (lat. 79° 25′ N.); and when the "Challenger" *Comatulæ* came into my hands I found the same type among a quantity of individuals of *Ant. eschrichti*, from a dredging in 51 fathoms a little to the south of Halifax. I have little doubt that it was also obtained by the "Vega." The "Willem Barents" met with it in 1880 near the locality of the Tegetthof dredging. Fielden's specimens were well and carefully described by Sladen,* who identified them with that dredged by the "Tegetthof," so far as he could judge from von Marenzeller's description of the latter. Thanks to the kindness of Dr von Marenzeller, I have been enabled to examine his type for myself, and I am satisfied that Sladen was right in identifying it with those dredged by the "Alert." After writing his description of them Sladen saw for the first time some examples of *Ant. celtica*, Barrett sp., and recognising that these were totally different from the Arctic specimens, he inserted a note to that effect, but did not rename the latter.

Barrett's type now turns out to be the long but little known *Antedon phalangium* of the Mediterranean; and the specific designation *celtica* being therefore unoccupied, I thought at first that it might conveniently be retained for the type described under this name by von Marenzeller and Sladen respectively.† This, however, has seemed undesirable for many reasons; and in compliance with the wishes of both the above named naturalists, I propose to give it a new name altogether. I have, therefore, chosen one indicative of the character by which the species is most easily distinguished from *Ant. eschrichti*, viz., the markedly quadrate shape of the middle and outer arm-joints, as has been noted above among the "special marks" of *Ant. quadrata*.

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* *A Memoir on the Echinodermata of the Arctic Sea to the West of Greenland.* London, 1881, p. 75, pl. vi. figs. 5, 6.

† "Note on the European *Comatulæ*," *Zool. Anzeiger*, Jahrg. iv. p. 520.

This type was doubtless met with by the "Porcupine" in 1869, somewhere or other in the cold area. But there were no examples of it in the remains of the collection of *Comatulæ* which have come into my hands. The "Triton" dredgings increase its bathymetrical range down to 466 fathoms, the "Valorous" Station in Davis Strait (410 fathoms), having been the deepest hitherto known. The three "Triton" specimens are all of them small, like those of the "Tegetthof" and "Valorous"; while they have a stiffer and less feathery appearance than the larger ones obtained farther north by the "Alert" and "Willem Barents." In fact, they more nearly resemble the small individual figured by Sladen * in their general characters. The dorsal processes on the lower joints of the basal pinnules are less prominent than usual; while the peculiar characters of the first two pinnule-joints in the outer parts of the arms are by no means so marked as in larger individuals. This feature is one which is more or less visible in all the Arctic species, reaching its best development in *Ant. eschrichti*.

Station List of Crinoids and Myzostomida, 1880-82.

H.M.S. "Knight Errant." 1880.

Station 5. Lat. 59° 26′ N., long. 7° 19′ W. 515 fathoms. Mud. Temp. 45°·4 F.

Rhizocrinus lofotensis.

Station 6. Lat. 59° 37′ N., long. 7° 19′ W. 530 fathoms. Grey mud. Temp. 46°·5 F. (Fragment only.)

Rhizocrinus lofotensis.

Aug. 4. On the plateau N.N.W. of North Rona. Lat. 59° 12′ N., long. 5° 57′ W. Rough ground.

Antedon rosacea, var.

H.M.S. "Triton." 1882.

Station 2. Lat. 59° 37′ 30″ N., long. 6° 19′ W. 530 fathoms. Mud. Temp. 46°·2 F.

Antedon dentata.

Station 3. August 8, on the Faeroe Banks. Lat. 60° 39′ 30″ N., long. 9° 6′ W. 87 fathoms. Sand and shells. Temp. 49° F.

{ *Antedon petasus.*
{ *Myzostoma cirriferum.*

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* *Mem. Arct. Echinod.*, pl. vi. figs. 5, 6.

Station 4. Lat. 60° 22′ 40″ N. and 60° 31′ 15″ N., long. 8° 21′ W. and 8° 14′ W. 327 to 430 fathoms. Stones; mud. Temp. 31° 5′ to 30° F.

Antedon quadrata.
Antedon eschrichti.
Antedon hystrix.

Station 5. Lat. 60° 11′ 25″ N. and 60° 20′ 15″ N., long. 8° 15′ W. and 8° 8′ W. 433 to 285 fathoms. Hard ground; stones. Temp. 43°·5 to 40°·8 F.

{ *Antedon dentata.*
{ *Myzostoma carpenteri.*

Station 6. Lat. 60° 9′ N., long. 7° 26′ 30″ W. 466 fathoms. Stones. Temp. 29°·5 F.

Antedon quadrata.

III. *On the Myzostomida of the "Porcupine" and "Triton" Dredgings.* By Prof. L. von Graff, Ph.D.

A. "Porcupine" Specimens.

1. *Myzostoma cirriferum*, F. S. Leuck.

Seven individuals were found on two examples of *Antedon hystrix*, P. H. Carpenter, probably from the cold area. This is a new host, the species having been hitherto met with only on *Ant. rosacea.* It has since been found on *Ant. petasus* as well.

2. *Myzostoma gigas*, Lütken, MS.

Hab. *Antedon eschrichti.* Station 57. Lat. 60° 14′ N., long. 6° 17′ W. 632 fathoms. Temp. 30°·5 F.

Two individuals were obtained, but in such a distorted condition that they cannot be accurately determined. As, however, the numerous *Myzostomida* infesting *Ant. eschrichti* at the most widely separated localities invariably belong to this species, those obtained by the "Porcupine" are probably of the same type. It will be fully described in the "Challenger" Report.

3. *Myzostoma alatum*, sp. n.

Hab. *Antedon phalangium.* The Minch. August 14, 1869. 60 to 80 fathoms.

Station 13, 1870. Lat. 40° 16′ N., long. 9° 37′ W. 220 fathoms. Temp. 52° F.

A species belonging to the type of *Myzostoma glabrum.* Dorsal surface arched and the ventral one hollowed, with a small muscular prominence in the centre. It is unprovided with cirri, and not transparent at the margin. Mouth ventral and cloacal papilla dorsal as in *M. glabrum.* Colour dirty yellow. Parapodia extremely short and reduced to annular folds, from the middle of which there project the brownish-black points of well-developed hooklets. These are closely grouped around the central muscular prominence; while the round suckers lie near the edge of the ventral surface.

A fully grown individual, 4 mm. in diameter, was so firmly attached to the disc of its host near the mouth that the hooklets remained in the perisome when it was removed. On its back was a young one measuring 1 mm. in its longer diameter. This differs from the adult in the presence of distinct papillæ on the dorsal surface, separated from one another by considerable intervals.

4. *Myostoma pulvinar*, sp. n.

Hab. *Antedon phalangium.* The Minch. August 14, 1869. 60 to 80 fathoms.

This species has a very singular form. It is transversely oval, 3·2 mm. wide and 2·7 mm. long; and it is thicker than any other free-living species. The dorsal surface is flat, while the ventral one is raised like a cushion, with the parapodia projecting round its edge at equal distances apart, as wide and blunt processes, at the points of which powerful hooklets are protruded for some distance. There are no suckers; while the mouth and cloacal openings, usually situated on the same side as the parapodia, are placed on the dorsal surface. Both this and the ventral surface are of a strong yellow brown colour. The only specimen obtained was closely attached to the perisome of its host. No other *Myzostomida* but *M. pulvinar* and *M. alatum* are known to infest *Antedon phalangium.*

B. "Triton" specimens.

1. *Myzostoma cirriferum*, F. S. Leuckart.

Hab. *Antedon petasus.* Station 3. Lat. 60° 39′ 30″ N., long. 9° 6′ W. 87 fathoms. Sand and shells. Temp. 49° F.

The single individual of *Ant. petasus* obtained at this station was harbouring no less than eighteen examples of this species, some adult and some young. It may have therefore yet another host besides *Ant. rosacea* and the new *Ant. hystrix* of the "Porcupine" dredgings. It has also been found on a specimen of *Ant. petasus* from Norway, in P. H. Carpenter's own collection; and likewise on another Norwegian example (from Arendal) in the University Museum at Kiel. No other species of *Myzostoma* is as yet known to infest *Ant. petasus.*

2. *Myzostoma carpenteri*, sp. n.

Hab. *Antedon dentata.* Station 5. Lat. 60° 11′ 45″ N. and 60° 20′ 15″ N., long. 8° 15′ W. and 8° 8′ W. 433 to 285 fathoms. Hard ground; stones. Temp. 43°·5 to 40°·8 F.

I have dedicated this species to my friend Dr P. H. Carpenter. It is of a dirty yellow colour, 2·3 mm. long, and of slightly greater width. Twenty short cirri appear at its margin, which is without a transparent rim. In fact, the whole disc is firm and opaque. The form of the ventral surface is most unusual, and there is no trace of the muscular prominence which is so generally present in its centre. This would indicate that the parapodial musculature is very weak. The parapodia themselves are extremely slender and short, being lodged in shallow pits close to the edge of the ventral side, and almost on the same level with the equally feeble suckers. Both mouth and cloacal opening are terminal. Attached to the dorsal surface of one of the two adults was an immature individual ·46 mm. long. The very characteristic differences betw en the two will be given in the "Challenger" Report, together with the specific diagnoses. This is the only species of *Myzostoma* which has yet been found infesting *Antedon dentata,* better known as *Antedon sarsii;* and it is as yet only known from the "Triton" dredgings.

5. On the Structure of the Pitcher in the Seedling of *Nepenthes,* as compared with that in the Adult Plant. By Professor Alexander Dickson, M.D.

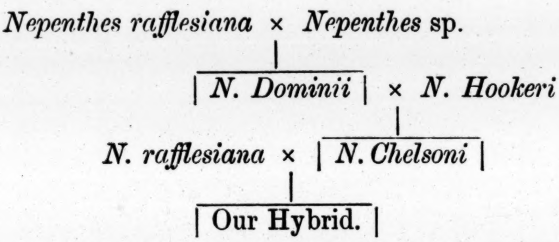
Preliminary Note.

The only observations, so far as I am aware, that have been made on the pitchers of *Nepenthes* seedlings, are those by Sir J. D. Hooker, who, in 1859, described their external configuration in his paper "On the Origin and Development of the Pitchers of *Nepenthes,* &c.," in vol. xxii. of the Linnean Society's *Transactions,* and afterwards added a few details of anatomical structure, in his admirable address on Insectivorous Plants, delivered at the Belfast meeting of the British Association in 1874.

This year I have had opportunitiy of examining *Nepenthes* seedlings from a large crop which our Botanic Garden Curator, Mr Lindsay, has raised from seeds of a female plant of *N. rafflesiana,* fertilised by pollen from *N. Chelsoni* (itself a hybrid).

In these seedlings the small lanceolate cotyledons are immediately succeeded by pitcher-leaves, which in form, as pointed out by Hooker, on the whole more closely resemble the pitchers of *Sarracenia,* than those of the adult *Nepenthes.* We have the entire leaf hollowed out into a funnel-shaped pitcher, with two largely developed wing-like expansions, and with a remarkably ciliated lid, whose base extends round fully one half of the orifice of the pitcher, very much as in *Sarracenia,* and very unlike the condition in the adult *Nepenthes,* where the *annulus* occupies almost the whole of the pitcher-orifice, the base of the lid being narrowed into a very small space. Our seedlings also exhibit, what Hooker has described, the convergence of the lateral wings towards each other above, and their union in the middle line, forming a transverse ciliated membrane below the orifice of the pitcher.

As regards further details, our seedlings differ somewhat from those described by Hooker. In the first place, Hooker describes (Belfast address) the inner surface of the pitcher as wholly glandular, while in our plants its upper half, or so, is eglandular and conducting, being thickly studded with the characteristic downwardly directed crescentic ledges. This difference between the two seedlings may be easily accounted for, inasmuch as there are some species of *Nepenthes* in which the entire inner surface of the pitcher is glandular (*e.g.*, *N. ampullaria* and *N. Hookeri*), and his seedlings may have belonged to some such species. The occurrence, indeed, of such a large conducting surface in the pitchers of our hybrid, is somewhat surprising when its origin is considered. In the *female* parent, *N. rafflesiana*, the conducting surface is limited to an inconsiderable area below the hinge of the lid; which area, when traced round the upper part of the pitcher, is seen to be reduced to a very narrow stripe, just below the line of inflexion of the annulus; while in the *male* parent, *N. Chelsoni*, there is practically no conducting surface at all, there being nothing left of it but the merest trace, running along below the said line of inflexion. The only suggestion I can make on the subject is that there may here be a reversion to some ancestor of the cross-bred *N. Chelsoni.* The following table represents the rather complicated genealogy of our seedlings, so far as ascertained :—


Nepenthes rafflesiana × *Nepenthes* sp.
N. Dominii × *N. Hookeri*
N. rafflesiana × *N. Chelsoni*
Our Hybrid.

It will be observed that the male parent of *N. Dominii* has not been recorded. On examining this form (which closely resembles *N. rafflesiana* in the limitation of its conducting surface), I have been struck with the great breadth and almost horizontal expansion of the *reflexed* portion of the annulus; and I would suggest that perhaps *N. Veitchii*, which seems (I only know of this plant by figure) to exhibit this character to a still more marked degree, may have been the parent in question.

In the second place, Hooker describes the first developed pitchers of his seedlings as destitute of annulus (*Linn. Soc. Trans.*, xxii. p. 418, footnote); while in ours this structure is very readily recognised, even in the leaf immediately succeeding the cotyledons, by its epidermis of imbricately disposed glassy cells, and its inflexion within the pitcher-orifice. As to this, I should almost be inclined to believe that the supposed absence of annulus was the result of an oversight, so distinctly developed is it in my specimens; not to speak of its universal occurrence in the adult *Nepenthes* plant.

Regarding the anatomical structure of these pitchers, there are several interesting points to note.

A. The *Pitcher-lid.*—This exhibits ciliary processes each tipped with a cell-group resembling that of a glandular hair. These processes, however, seem to be somewhat more than mere epidermal appendages, at least containing ground-tissue, as evidenced by the occurrence of the curious spiral cells which are developed so extensively in the ground tissue of these plants; and possibly they may represent prolongations of the entire leaf substance, like the tentacles of *Drosera.* Furthermore, there is no trace of the honey-glands which are to be seen on the lid of the adult form in both its parents; and in connection with this, it is interesting to note the absence of lid-glands in the adult of *N. ampullaria,* which species may thus be considered as exhibiting the undifferentiated or embryonic character.

B. The *Annulus.*—This is quite distinctly marked, and may be traced by its characteristically imbricate epidermis from just above the transverse membrane joining the wings up to the pitcher-orifice, where it is inflected as a slightly crenated margin. The most interesting feature of the *annulus,* however, is the presence, just within the inflexed margin, of small cushion- or button-like glands, resembling in general character the glands of the secreting surface in the lower part of the pitcher-cavity. In the first leaf and those immediately succeeding it, these glands are usually *three* in number (in one specimen I have seen only *two*). In the subsequently developed leaves they become more numerous, and in our seedlings now about a year old, as many as twenty of these glands may be counted along the margin of a pitcher about an inch long. They form a very pretty circlet—or rather semi-circlet—reminding one of the row of ocelli in an *Actinia.* The presence of these glands in the annulus, coupled with the absence of lid-glands, at once arrested my attention, and led me to suppose that here we probably had structures of greater morphological significance and of more universal occurrence than the glands of the lid, since these glands—physiologically important as they undoubtedly are—are not necessarily present in the adult plant. I have accordingly examined the annulus of a number of adult forms, and in this I have to acknowledge much valuable co-operation from my assistant, Dr J. M. Macfarlane. The result has almost surpassed my expectations. In all the species examined there is to be seen, immediately above the edge of the inflexed margin, a single line of small orifices alternating with the ridges of the corrugated annulus, and with their tooth-like prolongations when these are present. These orifices are the openings of canal-like fossæ, from the bottom of each of which a cellular nipple-like process or mammilla projects. These mammillæ are the apices of what may be termed the *Marginal Glands.* The glands are of very large size; the smallest I have seen—those of *N. ampullaria*—being $\frac{1}{37}$ of an inch in length, while in some other forms—*e.g.*, *N. destillatoria*, *N. phyllamphora*, and an undetermined form (apparently allied to the hybrid *N. Dominii*), for which our Garden was indebted to the late Miss Hope of Wardie, they may reach the enormous length of $\frac{1}{12}$ of an inch. The nipple-like apex just mentioned is never more than about $\frac{1}{200}$ of an inch in length, and is the only portion of the gland which is free, all the rest being immersed in the parenchymatous substance of the annulus. The cells composing these glands are of somewhat small size, and are very numerous. Those in the immersed portion are, in a general way, disposed in lines which pass obliquely inwards and towards the apex, the peripheral cells having a more or less transverse direction, while the central ones are longitudinally disposed. The superficial cells of the mammilla exhibit a beautiful columnar arrangement, being elongated at right angles to the surface. In some cases, especially in the larger forms, there seems to be a tendency to the formation of a central cavity from disruption from each other of the longitudinally disposed cells in the axis; but I should not be inclined to attach any physiological significance to this circumstance. In shape the marginal glands vary somewhat. In *N. ampullaria* the shape is ampullate, the nipple-like apex representing the neck, while the immersed portion, somewhat pointed at the base, and broadening upwards, represents the body of the ampulla. In the more elongated forms the shape is more or less cylindrical or sausage-like.

The marginal glands, it will be seen, are remarkable not only for their large size, but still more for their immersed condition—the other glands of *Nepenthes* (lid-glands as well as peptic ones) projecting entirely free from the surface, covered in though they may be by a pocket-like flap, or sunk at the bottom of a surface depression. In their *immersed* character, the marginal glands are perfectly comparable to the immersed glands of the secreting surface of the pitcher of *Cephalotus.* As to the function of these marginal glands, I cannot as yet speak definitely. Sir Joseph Hooker says (Belfast Address) that the pitcher-margins of *Nepenthes* always secrete honey; but from his making no allusion to these very remarkable glands, I am doubtful whether he refers to them or not. Probably, however, they are honey-secreting, and afford to the insect the last drops, just as it is on the brink of destruction.

C. The *Conducting* surface.—This agrees essentially with that in the adult forms. I have here to note that each crescentic ledge consists of a single semilunar cell, which overlaps a lower and smaller cell. Occasionally these two cells somewhat puzzlingly resemble deformed stomata, but I have not as yet been able to trace a more definite relation in this direction.

D. The *Secreting* or *Digestive* surface.—The epidermis cells here are remarkable for their wavy outlines, differing from the more angular form exhibited in the adult plants of the parent forms. The glands, moreover, are in the first-formed leaves entirely exposed, although in the later ones the rudiment of the protective pocket-like flap may be seen. In this connection Dr Macfarlane has pointed out to me that in *N. phyllamphora* the peptic glands are only to a very slight extent covered by flaps, so that in this plant we have the persistence of an embryonic character. In the first pitchers of the seedling the peptic glands are few in number—about ten; but in the later developed ones they become very numerous.